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Indexes for the previous 6 months will be found in the First number of July and the First number of January.

The Public Lighting Tables of the American Meter Company will be found in the page advertisement of that Company.

CONTENTS.

An Asterisk (*) denotes an illustrated article

NOTICE—
Wrinkle Department, The American Gas Institute..... 309
OFFICIAL NOTICE—
Change, Place of Meeting, Michigan Gas Association..... 309
EDITORIALS—
Briefly Told 309
Gas Literature Wanted—Current Comment.
*Bright Store Lights, by "Engineer"..... 310
The Concepts and Terminology of Illuminating Engineering, by Mr. Clayton H. Sharp 311
*A New Comparison Photometer, by Dr. Chas. H. Williams..... 313
*Illumination Photometers and their Use, by Mr. Preston S. Millar. 314
*A New Recording Gas Calorimeter..... 319
Priming Coats for Metal Surfaces: Linseed Oil vs. Paint, by Mr. F. P. Cheesman..... 321
ITEMS OF INTEREST FROM VARIOUS LOCALITIES..... 322
A Hint from Yuma, Ariz.—Gas Works for Camp Hill, Pa.—Annual Meeting, Lansing, Mich.—Not the First Pipe He Laid—Cleveland's Gas Royalties—Decline the Contract—Lighting Plants for Sherburne, N. Y.—New Capital for San Francisco Gas and Electric Company—Contracts Directed by Mr. H. I. Lea—Big Business for an Idaho Company—Clay Center, Kas., Wants a Gas Works—An Odd Suicide—Providence (R. I.) Gas Royalties—Personal—Annual Meeting, New Bedford, Mass.—Even in Darkest Africa—A *Resume*—Personal—Why Shouldn't They Think So?—A Brief Statement—Piping Times at Lynn, Mass.—Something from San Francisco—And Other Items.
The Market for Gas Securities..... 324

[NOTICE.]

Wrinkle Department, the American Gas Institute.

To the Membership, American Gas Institute: All members of the American Gas Institute, and others interested, are requested to contribute a description of any novel device or scheme covering any feature of the gas business. Every department of every company uses some novel stunt which would be of value to others. The object of this department is to compile such information. The value of the report depends entirely on the co-operation received. Send in your contribution at once to

MILAN R. BUMP, Editor,
60 Wall street, New York.

[OFFICIAL NOTICE.]

Change of Meeting Place, Michigan Gas Association.

MICHIGAN GAS ASSOCIATION,
OFFICE OF SECRETARY,
DETROIT, MICH., July 1, 1907.

To the Members, Michigan Gas Association: Owing to unavoidable delays in the completion of the new hotel at Kalamazoo, Mich., the Executive Committee has changed the place of meeting from Kalamazoo to Battle Creek, the meeting to be held September 18, 19 and 20, 1907. A notice will be sent in the near future giving full information in regard to hotels and programme, for papers as well as entertainment. Respectfully, ALONZO P. EWING, Secretary.

BRIEFLY TOLD.

GAS LITERATURE WANTED.—Mr. L. P. Lowe, writing to us from 1214 Polk street, San Francisco, Cal., under date of the 8th inst., says:

"My library of gas books, and subjects akin thereto, which I believe was the most complete one in existence, was destroyed in the April 18, 1906, disaster. In re-establishing this library, which will find an ultimate home with a gas association or educational institution, I am desirous of securing all available gas literature printed in the English language, including technical works, reports, pamphlets, etc., and will purchase such as I do not possess. Those having such works will accommodate me by sending a description thereof, stating condition of volume, and net price desired, carriage included."

CURRENT COMMENT.—

THAT the Consolidated Gas, Electric Light and Power Company, of Baltimore, Md., is not relaxing in any sense its efforts to augment its gas trading, and that it is eminently successful in that endeavor, are evidently authenticated when it is known that the Company took on 6,000 additional gas consumers last year. Now, while we do not wish to appear as instructing the Company in the least degree, there is one pipe extension that it should make. And we will put it up to Secretary Cohn to guess where that district is.

THE street lamps that are being installed—in fact, that have been installed—by Manager Nevins, of the Haverhill (Mass.) Gas Light Company, in accordance with the terms of the latest [illegible]

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AUG 19
SMITHSONIAN DEPOSIT.

ing contract in that city, are of the No. 100 type, with incandescent attachments.

A CORRESPONDENT forwards the following, under date of the 13th inst.: "Mr. H. F. Blossey, Superintendent of the Alton (Ills.) gas works, was threatened yesterday by a gang of Italians armed with knives, who declared their intention to kill him unless he paid them off. He had discharged the padrone, and the 12 men who had been paying tribute to the padrone for the privilege of holding their jobs, followed his lead in leaving the place. They demanded their pay, but as there is a rule with the Company to pay every 2 weeks, they were refused. When the gang invaded Blossey's office and demanded money he backed against a safe in the corner of the office, and, with a big club, warded off his assailants, and finally drove the whole 13 from his office, just as a squad of police arrived in response to a riot call."

MESSRS. GEORGE BRINE and T. K. Glenn have been elected Directors of the Georgia Railway and Electric Company, succeeding respectively Messrs. A. E. Thornton, deceased, and W. Lee Cosgrove, resigned. Mr. Brine will perhaps be more readily identified when it is mentioned that he succeeded Mr. Cosgrove as President of the Atlanta (Ga.) Gas Light Company.

IT looks to a certainty that Gadsden, Ala., will have gas before next winter, an important interest in the proposed Citizens Gas Light and Fuel Company for that place having been purchased by Mr. H. C. Higgins. Messrs. T. H. Stephens and John B. Hammond, to whom the original franchise was granted, still remain connected with the enterprise. Mr. Higgins is a resident of Dixon, Ills.

MR. EDWARD J. JEANNOT has been appointed head of the new business department in the campaign for trading that is being instituted in Quebec, Canada, by the American Light and Power Company.

MR. JACOB JARVIS has been elected Secretary and Treasurer of the South Range (Mich.) Gas Company, vice Mr. P. A. Sheehan, resigned.

THE Utah Gas and Coke Company, of Salt Lake City, has notified the residents that the prices of coke until further notice shall be: $6.25 per ton, in the Company's sheds; $6.75 per ton, delivered at places of use. An additional charge of 50 cents per ton will be made when shipments put up in bags are ordered.

THE works' employees of the Lead-Deadwood (So. Dak.) Gas Company recently quit work because their demands for an 8-hour shift were not acceded to.

THE generating plant of the Peoples Gas and Electric Company, of Oswego, N. Y., is being increased by the placing of 2 benches of sixes. The use of gas in Oswego is expanding with amazing rapidity.

THE generating plant at Beaumont, Tex., was badly damaged by fire some days ago. Luckily, though, the generators were reparable.

THE new badge for distinguishing the employees of the Consolidated Gas, Electric Light and Power Company, of Baltimore, is in the shape of an incandescent electric lighting bulb, on which the word gas is prominently shown. It certainly indicates that its wearer is on a "lighting job."

THE people of Southbridge, Mass., are seemingly quite pleased over the initiation of the $1.50 per 1,000 all around selling rate for gas. Heretofore the rates were: On lighting account, $2 per 1,000; for fuel use, $1.50.

A CORRESPONDENT in Fall River, Mass., writing under date of the 10th inst., inclosed the following: "The Fall River Gas Works Company has made an addition to the equipment at its plant at the foot of Anawan street. The addition is not to the generators, the machinery or the gasholders, but it is in the form of an improvement that will be appreciated by every one of the large force of men employed there. It comprises two new rooms, one for recreation and the other a bath room, with all of the most desirable kind of equipment. The rooms are in the brick building close to the Anawan street entrance to the plant, are on the ground floor and easily reached from all parts of the plant. The recreation room is reached through a door from the yard. It contains a large table and comfortable seats, has many metallic lockers, plenty of ventilation and is well lighted. Each employee has a locker and a key to it. The bath room is off the outer room. Like the recreation room, it has an asphalt floor, and with its marble finish and visible plumbing of nickel it presents a most attractive appearance. There are compartments for shower baths and every other convenience that could be desired. The bath room is piped for hot and cold water, and, in fact, nothing that will add to the comfort of the employees while about the plant, has been overlooked."

Bright Store Lights.

Communicated by "ENGINEER."

We are prompted to write further details concerning the bright, white lights of the modern store fronts, owing to the rapidly increasing introduction of gas arcs for this service. I find that very many important stores of the country are changing over their system of lighting so as to get some lamps out in the front, where the sidewalk may be lighted and even the street front illuminated with the same lights that cast rays of brightness into the store windows where the goods are exhibited. In olden times it was the aim to get bright lighting of show windows of the big stores in the rear of the goods. Often the lights were arranged in tiers above or below. Sometimes wings were adjusted so as to permit the light to cast its rays into the goods from the sides; but the overhead system, the footlight row plan, the wind method, and in fact all of this description of lighting produced a lot of shadows. Dark places in exhibition windows were always the means of discrediting forms of show window lighting for exhibition purposes, and many of the store people did not use the window lights at all; but with the advent of the gas arc system, by which it is possible to get bright, white lights in front of the goods by having the lights on poles, brackets or other supports in direct front of the windows, whatever shadows are cast, are cast back of the goods where no harm is done. The front of the goods are completely illuminated, which is all that the store proprietor desires.

Because of the possibilities of the street window front gas arc the owners are installing them. Hence this article refers to some of the successes and failures of the arc lights for this line of work. Whatever the line of mechanical improvement which may be made in the art of lighting a store front, you can always look for just enough botch work, and poorly planned fixtures and lamps, to create defective systems in certain places. While many of the pipe fitters of the city or town are careful to plan the lighting system correctly and install it so that the lamps can be utilized to good advantage, many of them are careless and seek to get the work finished by contract time and price, regardless of the results. Therefore your correspondent found some good gas arc lights in positions where they were quite non-effective so far as lighting the interior of the window fronts was concerned, for all of the light was cast somewhere else. I saw brilliantly lighted roofs of awnings, and found cases in which the windows of the other man's store received most of the light. Also instances in which an extremely brilliant street front and walk were acquired at the expense of a shadowy window. I observed cumbersome piping arrangements drooping over the walks, threatening the passer by, for these weighty, bulky devices are liable to be torn from their fastenings during a heavy wind. I saw that in some places the object was to get a front light with a view of drawing notice to the store front, so that these lights were arranged to cast their rays along the street, ignoring the interior of the window. In order to make both windows and street bright, two systems of lights are often used.

I noticed one instance in which a tier was employed for the street, another tier for the sidewalk, another for the window showing. From the direct front you could see only a brilliantly illuminated front. The only way to observe what was in the window was to get within the circle of light of the window tier. Hence the 3-tier system in this case failed in this degree. Then the writer discovered arrangements as in Fig. 1, in which the parties installing a single lamp for lighting a show window of a shoe store put up the lamp regardless of the awning. You will find that practically all of the stores on the sunny side of the street have awnings, which may not be used every day, hence the day you put up the lamp the awning may be folded back and out of the way, but as soon as there is a storm, or when the sun shines, the awning is dropped and frequently the store people neglect to lift it at night. Or the awning may be fixed in position—perhaps it is arranged to support a porch for the establishment above - therefore, when the lamp is hung as at *A*, your rays are obstructed in the area of light, as at *B* and at *C*. In order to overcome the evil effects of the portable or stationary awning, a good way is to hang the lamp below, as in this same view, at *D*. It will not matter in which direction the rays are cast backward or sidewise. You get the light into the window at *E*, which is the chief mission of the arc for this work. I note they are using gas arcs quite freely in lighting the window and door schemes of modern store fronts, as shown in Fig. 2. This description of store front involves the setting back of the door about 10 feet from the line of the show windows on the sidewalk. The object is to get greater window showing space. The line of windows, extending on either side of the door at an angle, represents the gain

in exhibiting space for the goods in the windows. This alcove is often built up and over with artistically designed stone or cement blocks. Novelty is sought for. Some antique designs are reproduced to the satisfaction of the store man who desires something different from what his competitor has. With ordinary lighting these depressed entrances to stores would not be very attractive; but the present plan includes the hanging of a gas arc, as at *E*. The arc lamp is supported in the center, and it has an excellent opportunity to cast its rays to the right, left, backward, forward and upward. There are not many obstructions to the light in this case. The strong light gives brilliancy to the goods in the windows, and jewelry store owners are adopting this plan of lighting the exterior of windows. When a window of this kind is correctly lighted, and is furnished with the glistening baubles of such stores, the degree of brilliancy is very attractive. The lamp being hung in the middle at *E* the direction of the positive rays is straight into the windows, as indicated at *F, F*. But of all the systems of exterior window lighting of stores, the plan exhibited in Fig. 3, of the series of windows in a large store,

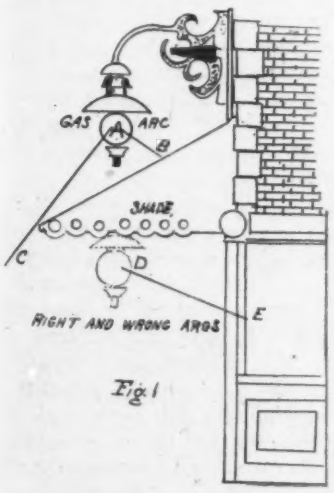

Fig. 1

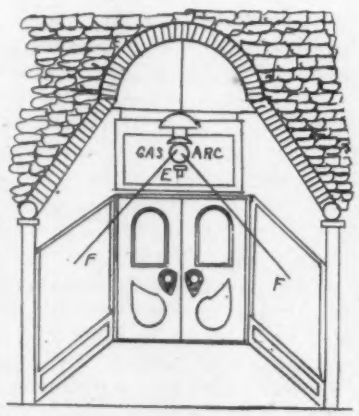

Fig. 2

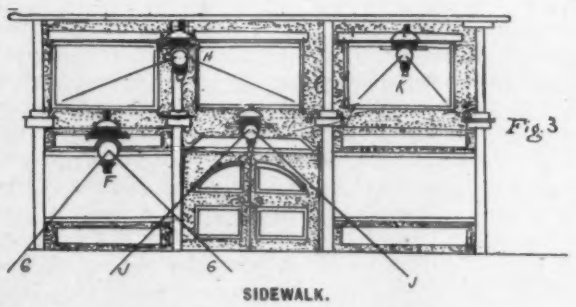

Fig. 3

is probably the most interesting. The best of our men have more or less trouble in getting the lamps properly set up.

I have witnessed repeated overhaulings of the lamps and have seen all the lamps taken down after the first night's trial and replaced the next day. I have seen men get impatient and have heard them use positive language. In the building plan, herewith shown, a lamp was installed in the center of each lower window. This made it right for the people to see in who were close to the window, but the strong light prevented anyone passing in a car or on the opposite side of the street from seeing the goods, hence the lamps were lifted well up, as at *F*, so that the rays reached the walk at *G, G*, and to the same area on the other side inside the window. A lamp was also hung in the center of the door. Then lamps were hung as at *K*, in the center of the upper tier of windows in which goods were placed on exhibition. This mode had to be discarded and the lamps were put in between the upper windows, as at *H*. Manufacturers of automobiles are using the upper windows for exhibiting their machines. A large plate front is put in and the outside arc lamps are arranged to throw the light on the motor-vehicle in the window. The industry is increasing steadily. Within a few years we will see many more of the advertising or show windows of stores and manufacturing establishments illuminated with gas arcs. It is a promising business and well worth the while to boom.

MR. A. J. WONES, of Covington, Ky., has been appointed Manager and Superintendent of the Owensboro (Ky.) Company.

The Concepts and Terminology of Illuminating Engineering.

[Presidential Address of MR. CLAYTON H. SHARP, Boston Meeting, Illuminating Engineering Society.]

In the infancy of a science the concerpts regarding it are necessarily neither very clear nor definite. The terminology of a science always lags far behind the actual state of the science itself. We must have the thing before we have a name for it—we must have the concept before we have a word to express it. An exact terminology, as contrasted with a loose one, is found to be more and more essential in proportion as its concepts develop and as the science itself progresses in exactitude. As long as the treatment of the science is qualitative only, no particular need is felt for an exact terminology. As however, the science becomes quantitative and involves exact measurements of the quantities entering into it, the need for a terminology which is correspondingly precise is felt. For instance, in the earlier days of the science of mechanics, no strict differentiation was made between the terms force, work and power. At the present time, however, these concepts and the terminology corresponding thereto are very clearly differentiated. The interrelations of things are not seen in the same way when a science is young, as they are when it has, so to speak, reached its maturity. The simplest and most obvious relations are the ones which first are used, and it is only with advancing knowledge that the utility of the less obvious relations comes to be appreciated. This is true for an applied science as well as for a pure science. In the application of scientific principles and industrial products to the uses of everyday life, it usually happens that the practitioner at first proceeds in a purely empirical way. He is likely, however, very soon to find a need for greater exactitude in his work; consequently his terminology, which at first was of the crudest description, becomes more exact and perhaps more complex. His concepts of what he is working with, which at first are inexact and hazy, necessarily become clearer with time; and he finds that the ideas on which he proceeded at first, while they may have been more or less correct, yet are not the ones which are most useful in the more extensive practice which time has brought. It may be useful to illustrate these abstract ideas by a few concrete examples.

Going back into the history of electrical science and of electrical engineering, we find that the earliest electrical conception was that of a force or tension or pressure. The idea of such a thing as a flow of electricity did not become established until after Volta's discovery and the pioneer work of Davy, Faraday, Ohm and and others had this concept to light, and in Ohm's law a relation between the fundamental electrical qualities was established. It was very many years before the terminology of electricity became in any sense systematized or exact. When, however, electricity ceased to become a pure science and came to be applied to the very practical problem of artificial illumination, so that electric power was generated in large quantities and became a commercial product, the need for a terminology, and for units of measurement and for measuring instruments, all made themselves felt, and the terms volt, ohm, ampere and watt came quickly into existence and into the everyday language of the science.

The science of magnetism furnishes another example. The obvious thing about a magnet is its attractive force for other pieces of iron. This force is concentrated at points near the ends of the magnet, which points received the names of "poles." When investigators began to study magnets critically, the most apparent thing to do was to measure the force or strength of these poles. On measurements of pole strength the whole science of magnetism was based. The theory of magnetism, however, went on in its development, and the ideas of lines of force and of flux of magnetism were introduced. Later, when magnetic calculations became a feature in the commercial design of dynamos and motors, the old concept of pole-strength was found to be too awkward and cumbersome as a basis for making such calculations and had to be abandoned in favor of the newer one of magnetic flux, doubtless to the great temporary inconvenience of those to whom the pole strength concept was a familiar one and the magnetic flux concept an unfamiliar one, acquaintance with which was to be gained only at the expense of considerable mental effort and inconvenience.

We are led now to ask what is the state or condition of the science of illuminating engineering in regard to its terminology and its concepts. This science is founded on the ancient science of optics. All the optical principles which apply to illuminating engineering have been known for many years. Optics is, in many respects, an exact science. The laws of reflection, refraction, diffraction and polarization have been studied with minute care. The meas-

urement of wave-lengths and angles of rotatory polarization, as well as the computation of lenses, mirrors and other optical apparatus, have been carried to an extraordinary degree of precision. In spite of all this, however, the science of optics has remained in a rudimentary condition in so far as its terminology and concepts relating to light as an output, used for purposes of illumination, are concerned.

Just as in the case of magnetism, where the elementary notion of pole-strength was long regarded as the fundamental point of departure of calculations, so the strength or intensity of light sources has been the principal concept in dealing with light as a product. Until touched by the quickening hand of practical application, until illuminating engineering began to take its place as a quantitative science, measurements of the candle power of luminous sources were all that were required, and by candle power was usually meant the candle power in a given direction. At the present time there are many signs that this branch of optical science is following the same course of progress which magnetism has taken before. Within a very few years the term "mean spherical candle power" has come into use among engineers. This marks a distinct advance in the practical application of illuminating engineering, since it implies a recognition of the difference between a candle power in a given direction and the average candle power in all directions in space. The notion of intensity of illumination, as distinct from intensity of a luminous source, has become a familiar one and an awkwardly named unit for it has been used. These are sure indications of the practical progress of illuminating engineering.

What should be, or are likely to be, the lines of further development? These may be determined, in some directions, largely by action which our Committee on Nomenclature and Standards may take. In other directions this committee will be impotent, since it cannot enforce the adoption of its recommendations in practice. The practitioner must feel the need of some novel term or idea before he will adopt such term or idea. Such a need is sometimes unfelt because the practical value of novel terms and concepts is not clearly enough recognized by those to whom they would be useful. Having this in mind, I desire to bring to your closer attention the bearing of some terms and concepts which have not, I believe, established themselves in the practice of illuminating engineering to the extent to which their practical convenience and utility entitle them.

At the present time, in his quantitative work, the illuminating engineer deals chiefly with candle power in its various aspects and with intensity of illumination. He does not, as a rule, employ any term which expresses directly the quantity of light which is being emitted by the source with which he is dealing. This is surprising, for the quantity of light which he had at his command is of vital importance to him. The distribution of this light he can arrange according to his own wishes by the use of various devices. Now the proper term for the quantity of light is easily found by a consideration of the physical nature of light itself. Light consists in ether waves propagated with a velocity of 300,000 kilometers per second. A source of light is simply a wave maker. It agitates the ether continually and sends out a constant stream or flow of such waves in all unobstructed directions. If we take any transparent plane on one side of which is a source of light, we may think of a continual flow of wave-trains in the ether across this plane. If we surround our source of light by a closed, transparent surface, say an imaginary sphere, the total flow of ether-trains through this surface measures the luminous output of the source. For the sake of uniformity with the usages of other branches of physics, etc., the wave flow is referred to by using the Latin name for flow, namely "flux."

We should form a concept, then, of all sources of light, whether primary or seconary, as the starting points of a luminous flux, and of all spaces surrounding such sources of light as traversed by this luminous flux. Having formed the concept of luminous flux, the following definitions and relations are a direct consequence: The output of any lamp is measured by the total luminous flux which it emits; the brightness of a diffusely reflecting or transmitting snrface is proportional to the luminous flux which it emits per unit of area; the reflecting or transmitting power of such a surface is the ratio of the luminous flux which it emits to that which it receives; the intensity of illumination on any surface is the flux which it receives per unit of area. All the above quantities are of vital importance in illuminating engineering, in view of which fact it would be surprising if the concept of luminous flux should not prove itself to be very useful in the everyday work of the illuminating engineer.

It is necessary first to define a unit in terms of which luminous flux is to be measured and to esfablish its relation to the unit of luminous intensity, the candle power. This is done in a way analogous to that employed in magnetism and electrostatics; that is, unit flux is defined as the flux emitted by a light of unit intensity, or 1-candle power, in a unit solid angle. A unit solid angle is the solid angle subtended at the center of a sphere by a portion of the surface of the sphere bounded by 4 lines, each equal in length to the radius of the sphere. There are 4 — or 12.57 such solid angles in the entire sphere. This being the case, we have approximately the relation that a unit solid angle is the one subtended at a point by a surface 1 foot square, 1 foot distant from that point, or by a surface 1 meter square 1 metre distance from the point, or a surface 1 yard square 1 yard distant from the point, etc. If at the apex of such a solid angle a light source of 1-candle power be placed, a unit luminous flux will pass through any transverse plane through the solid angle, no matter what the inclination of the plane or its distance from the light. In terms of this unit, luminous flux is measured.

The relation between the total luminous flux of a source of light and the mean spherical candle power of that source is at once seen. If we consider a source of light having an intensity of 1-candle power in all directions, its mean spherical candle power would be one; and since there are 4 — solid angles in a sphere surrounding that source, the total flux from it will be 4 — unit of flux. If the mean spherical candle power of a source is — its total flux will be equal to 4— — or — equals 4— —, where — represents the total flux and — the mean spherical intensity. Thus the total flux is numerically equal to 12.57 times the mean spherical candle power of the source.

We have next to consider the relations existing between flux of light and intensity of illumination. As we have seen, the flux falling on a plane surface 1 foot square placed 1 foot distant from a light of 1-candle power is approximately a unit flux. But the illumination on that surface is unit illumination if we measure in English units. If the same plane surface is removed to a distance of 2 feet from the light, only one-fourth of the total flux falls on it and the illumination is one-fourth as intense. In other words, the intensity of illumination on any surface is measured by the luminous flux per unit of that surface or by the flux density. This relation may be expressed thus: E . From this relation the familiar inverse square law may at once be deduced.

The above equation becomes of practical importance in computing average illumination results. If, for instance, we know that from a given source or sources of light a certain flux falls upon the plane of reference, we can determine at once the average illumination on this plane by dividing the flux by the area of the plane. Thus the average illumination is determined without direct reference to the candle power of the sources. Conversely, measurements of illumination on a given plane enable us to determine the flux of light falling on that plane. This is a quantity of great importance, since it leads us to a value for what we may term the net efficiency of the installation, or the efficiency of utilization of the light. By the net efficiency of the installation, or the efficiency of utilization, would then be meant the ratio of flux which falls upon the horizontal plane of reference, to the total luminous flux emitted by the lamps in the room.

In order to make the use of the notion of luminous flux, a convenient one in practical work of the computation of illumination, it is necessary to use it also with reference to the sources of light employed. In other words, when we wish to arrive at average values for illumination rather than exact illumination curves, we may ignore the candle power and the distribution of luminous intensity of the lamp and may start out from a value for the flux of light which the lamp, together with its reflector or globe, sends in the direction of the plane of reference. Multiplying this flux by the number of lamps, and dividing it by the area of the plane, we have approximately the illumination on the plane, neglecting reflections from walls and other objects. The effect on the flux of multiple reflections by the walls of the room can be found according to the usual procedure, that is, the flux must be multiplied by , where K is the average co-efficient of reflection of the walls and ceiling, and where this value is subject to large modifications according to the location of the lamps in the room.

The maximum and minimum points of the illumination in a given installation can usually be told at a glance, and the values of these illuminations can be computed if required. The advantage of the procedure outlined above is that it gives an average value for the illumination over the entire plane of reference without the necessity for going through the computation of the actual illumination at a large number of points in the room.

The procedure for determining the value of the luminous flux from

a lamp, either its total flux or the flux within a certain solid angle, is similar to that pursued in determining the mean spherical candle power and mean hemispherical candle power, etc. For instance, the well known Rousseau diagram, so generally employed for the determination of mean spherical candle power, is really a flux diagram. If the Rousseau diagram extends over 180° polar distance, the total area which it incloses is proportional to the total flux of light from the lamp and the part which is inclosed between any two angles as marked on the axes of the abscissas, is proportional to the flux from the zone or from the solid angle. Consequently, any method which will yield the mean spherical, mean hemispherical, or mean zonular candle power, will give, with practically no modification, the luminous flux corresponding thereto. The Matthews integrating photometer may be calibrated so as to give directly the total luminous flux from the lamp measured by it, or other integrating devices may be employed. By the use of such devices as are at hand to-day, it would not be at all impossible to rate lamps according to their total luminous flux rather than according to their candle power. Thus at one stroke the difficulty would be cleared up which arises from actual difference in performance of incandescent electric lamps, which are rated alike according to our present arbitrary method. Using one of the methods indicated above, it is a matter of no difficulty to determine what the total flux of light will be, for instance, from a lamp with a conical reflector inside the angle subtended by the sides of the cone. Imagine, then, a number of lamps with such reflectors illuminating a room, and so placed that the angles of the cones of the reflectors do not in any case fall outside the boundaries of the plane of reference. Then the total amount of light which these lamps are throwing on the plane of reference will be approximately equal to the number of lamps multiplied by the flux which is sent out inside this plane, and as said above, the average illumination is obtained by dividing this flux by the area of such plane. This method is of such extreme simplicity that it seems that it ought to be developed in practice. It is concededly approximate, but since any method yields results which are so strongly affected by the reflections from walls and ceiling, it is a question whether an approximate method like this might not in the end yield results which are quite as reliable as those which are obtained by the more laborious calculations involved when illumination curves are computed.

Having pointed out certain reasons why the notion of luminous flux should find extensive application in illuminating engineering work, let us consider for a moment the question of terminology. We have at the present time a name for the unit of luminous intensity. We call that the candle, and we measure luminous intensities in candle power.

It is usual in this country to express illumination in terms of the candle, and of the foot as the unit of distance. We have no suitable name for this unit of illumination; by some it is called the candle-foot, by others the foot-candle. Some make the plural candle-feet, others make it foot-candles. The name is inappropriate and awkward, since ordinarily, when we place two words in conjunction like this, we mean the product of the two quantities involved, as for example in foot-pounds, where we mean the product of the feet by the pounds. The foot-candle or the candle-feet, however, means candles divided by, not feet, but feet squared; consequently the term is doubly inappropriate. It would, therefore, be very desirable, if we are going to adhere to this unit of illumination, to have a suitable name for it. If we use the metric system, a name for the unit of illumination is at once at hand. In this system the candle may be the unit of luminous intensity, but the meter is taken as the unit of length. The illumination produced by 1 candle at a distance of 1 meter is called the "lux." On account of the relation existing between the foot and the meter, it happens that the lux is about 10 times the size of the foot-candle. To be more exact, it is or 10.8. The use of the lux, however, involves the use of an unaccustomed unit of length and it is consequently found awkward. This is all a matter with which the Committee on Nomenclature and Standards will undoubtedly deal.

When it comes to the unit of flux of light, as we have seen the unit of length does not enter. The unit of flux depends only upon the chosen unit for luminous intensity and consequently we may adopt the name which has already been suggested and used for this purpose, namely, the "lumen." By the lumen we mean the flux of light emitted by a source of 1-candle power through a unit solid angle, and, as we have seen, the number of lumens falling on a surface, divided by the area of the surface in square feet, will give the illumination in foot-candles, or the number of lumens falling upon a surface, divided by the area of that surface in square meters, will give the illumination on that surface in lux. It would, therefore, seem to be an obvious thing to do to adopt the lumen as the name for the unit of luminous flux.

A point in terminology, which it may not be out of the way to bring up at the present time, relates to the use of the term "efficiency" in illumination work. We have in this kind of work at least three kinds of efficiency to consider. We have, first, the efficiency of the illuminant as such; second, the efficiency of the illumination installation irrespective of the lamp (this may be called the net efficiency of the installation, or the efficiency of utilization of the light); and, third, the efficiency of the installation including the lamp (this may be called the gross efficiency of the installation). The efficiency of the lamp, if it be an electric lamp, would properly be determined by its lumens per watt; this term has not come into use, but deserves to do so. Instead of lumens per watt, we speak of watts per candle. Watts per candle measures for a given type of lamp, the specific consumption of that lamp. True specific consumption would be measured by watts per lumen. The term watts per candle, while a very convenient one from the lamp maker's point of view, is not so good a term for the use of the illuminating engineer. It is to be hoped, therefore, that in time lamps will be designated by their efficiencies, and the efficiencies will be expressed in terms of lumens per watts. What we ordinarily at the present day call a 16-candle power 3.1 watts per candle lamp would, under that system, have a rating of 163 lumens and an efficiency of 3.3 lumens per watt. In the case of gas lamps, the efficiency could be expressed in terms of lumens per cubic foot per hour.

Going next to the net efficiency of the installation, irrespective of the lamp. This is the efficiency which it is the especial province of the illuminating engineer to attend to. Given any illuminants whatever, there is some best way to equip and to arrange them so as to produce a maximum result in illumination. This efficiency may be expressed in terms of the lumens received on the horizontal plane of reference, divided by total lumens emitted by the lamps. The gross efficiency includes the efficiency of the lamps themselves. This is the efficiency with which the user of the installation, the man who pays the bills, is most interested. This efficiency can be expressed in terms of lumens on the plane of reference per watt, or per cubic foot per hour expended in feeding the lamps. In the *Transactions* of this Society it has appeared that the need is felt for an expression of the gross efficiency of an installation, since the term foot-candles per watt per square foot has been used for this purpose. Those who have used this term have recognized its awkwardness as well as its usefulness, and it has even been proposed to give a name to this unit. If we stop, however, to analyze this expression, we see that foot-candles per watt per square foot is equivalent to foot-candles multiplied by square feet, and divided by watts. But, as we have seen, the foot-candles multiplied by the square feet gives the luminous flux in lumens, consequently the expression foot-candles per watt per square foot is equivalent numerically to lumens per watt; so that here again the introduction of the notion of luminous flux, and of the term lumen, justifies itself by reducing an expression of unusual complexity to one of very great simplicity.

This address as a treatise on the concepts and terminology of illuminating engineering is necessarily indefinite and incomplete. Its purpose is to point out the utility of certain ideas and names which should prove useful in the pursuit of the theory and practice of illuminating engineering. What the ultimate developments will be in concepts and terminology of the science cannot be foretold; the most obvious steps in advance are those outlined above.

A New Comparison Photometer.

[A paper read by DR. CHAS. H. WILLIAMS, at the Boston Meeting, Illuminating Engineering Society.]

The object of this photometer is to provide a compact and portable instrument for measuring in foot candles, or other units, the light reflected from surfaces, such as the walls of a room, the paper on a desk, etc., in order to determine whether one method of lighting is better than another, whether school rooms are properly lighted, and, in general, to measure the light reflected from an illuminated surface as compared with a standard illumination.

The principle of the photometer is this: The object to be measured is looked at directly through a semi-circular opening in the photometer; through another similar opening the light from a small electric lamp attached to the photometer is brought by means of a prism in such a direction that the eye sees a disk of light, the right half of which comes from the object to be tested and the left half from the

photometer lamp. If the intensity of the two halves is equal, it shows that the intensity of the illumination due to the object and the standard are equal. If they are unlike, the intensity is reduced on one side by means of a movable photographic film of gradually increasing density, until the two halves of the field are equal. The scale on the film gives the illumination due to the object as compared with the standard.

The photometer is a small, thin, metal box, Fig. 1, 3 inches square by 1 inch deep. At *A* and *B* are the two semi-circular openings in the box. Over the opening *A* is a closed tube containing at its further end a small, tipless, 5-volt lamp, and at the other end near the opening a piece of fine ground glass. *E* is the prism and *F* is the tube through which the light and object are seen. *G* and *H* are strips of glass about 6 inches long by 1 inch wide, carrying the photographic films, which can be moved vertically before each opening, so that the light at each opening can be made more or less intense at will. On the handle supporting the box is a contact device, so that the thumb can light the photometer lamp when a measurement is to be made, the current being supplied by a small storage battery.

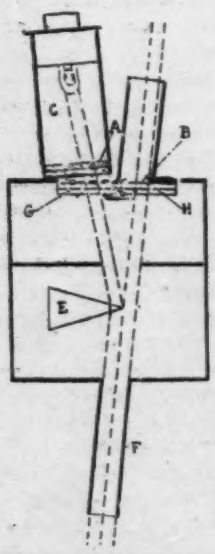

Fig. 1.—Arrangement of the Illuminometer.

To use the instrument it is first compared with some standard lamp placed at such a distance from a piece of rough, white Bristol board, that the surface of the board receives an illumination of 1 foot candle. The photometer now has the photographic film before the opening *H* placed at zero, so that no light is absorbed by this film, the other film before the opening *G* is moved up and down before the opening until both halves of the field, as seen in the tube *F*, are equal. The lamp of the photometer is then giving on the ground glass an illumination equal to 1 foot candle of illumination as viewed by the photometer.

In order to measure the illumination of objects in the room, such as the light reflected from the walls, etc., we leave the film at *G* unchanged in position, and while looking at the object through the film *H* we move this film until the 2 halves of the field are again equal and read off, from a scale attached to the film, its position, and from a calibrated chart we can then get the intensity of the illumination of the object looked at in foot candles.

If the object to be tested has an illumination of less than 1 foot candle, we leave the film *H* at zero, move the film *G* to a position of less density until the field is equalized, and read from the scale the position of the film to get the fractions of 1 foot candle of illumination.

After all the measurements are finished, we again test the photometer by comparing it with the original source of standard light, the film *H* being at zero. If we find the same position of the film *G* that was found in the first setting before the measurements were begun equalizes the 2 halves of the field, it proves that the comparison lamp of the photometer has not varied in its intensity, and this checks up the photometer both at the beginning and at the end of the measurements in a way that is not easily done with other instruments. With a storage battery of about 5 volts and a small tipless lamp of the same voltage, we get a light which is sufficiently steady for an ordinary test.

In all comparisons of daylight and artificial light, and with light reflected from different sources, we often get a troublesome difference in color in the 2 halves of the field. This can, to some extent, be helped by placing a light blue glass in addition to the ground glass in the tube *C* before the comparison lamp; but it is surprising to see how quickly and with what small errors the setting of the films can be made to give an equalization of the 2 halves of the field even with differences in color, and this is helped somewhat by the fact that these photographic films are neutral and non-selective in their effect on colors. They are the same films which have been for some time used at the Harvard Observatory in some of the astronomical work.

Where measurements are made of surfaces illuminated by artificial light, the color difference between such light and the photometer lamp is less marked than it is between daylight and the lamp. Street lighting can be measured by holding a piece of white Bristol board normal to the direction of the light at a uniform distance from the street lamps to be tested, and measuring, with the photometer, the amount of light reflected from the board.

Illumination Photometers and Their Use.

[A paper read by MR. PRESTON S. MILLAR, Boston Meeting, Illuminating Engineering Society.]

In this discussion, instruments which measure the chemical or calorific effects of lights are not considered. The illuminating engineer is concerned more particularly with instruments designed to aid the eye in determining the illuminating effect of light. These may be classified broadly as photometers dependent upon visual acuity, and those in which the illumination to be studied is compared to that produced by a standard light source.

Visual Acuity Photometers.—The principle of visual acuity, as generally applied, depends upon the detection of the vanishing point of an effect produced by the light to be studied. In some cases it is the disappearance of a figure or character; in others, the disappearance of a contrast. Such instruments, being based upon the ability of the eye to see or distinguish objects, yield results which are proportional more nearly to those qualities of light which make for visibility, than to its intensity. They are known as visual acuity photometers, or illuminometers.

There are fundamental difficulties with this extinction method which render it unsuitable for important work. These are the inability of the eye to judge of the point of disappearance with precision; the susceptibility of the eye to the influence of environments and conditions; the necessity for reducing the light to low intensities at which the "Purkinje effect" operates to distort results; and the errors encountered in effecting this reduction.

The decided advantages which this method can boast are simplicity, absence of expensive adjuncts, and minimum demand for technical knowledge and skill on the part of observers.

Illumination Photometers.—The only photometers which may be relied upon in engineering work to yield reliable values are those in which a comparison light source is used, and reliance is placed upon the ability of the eye to judge equality of illumination. The essential features of such photometers are:

First, a photometric device; second, a comparison light source; third, a means of varying the intensity of the illumination produced upon the photometric device by the comparison light source; fourth, a test plate upon which the unknown light falls.

Photometric Devices.—These may be divided into three groups: First, arrangements of prisms whereby surfaces illuminated by the comparison and the test light sources may be viewed in one field with indistinguishable line of separation. Such devices are characterized by maximum sensibility and ease of comparison, but are generally difficult and expensive of construction. Particularly with low intensities they are superior, working with fair sensibility on intensities quite below the range of other devices. The Lummer-Brodhun photometer is a notable example of devices of this kind.

Second, screens of varying translucency, the opposite sides being illuminated by the comparison and test sources respectively, and being viewed through prisms or mirrors in contiguous fields. The Bunsen photometer is the well-known example of this class of photometric devices. Various adaptations of the Bunsen photometer are used very largely in photometric work in this country. In general, they fall but little short of the prismatic devices of the first class in respect to sensibility and ease of comparison, and are simple and inexpensive of construction.

Third, the various devices whereby the illumination intensities produced by the comparison and test light sources respectively are viewed in contiguous fields with well marked line of separation. In this class may be found the Bouguer screen, the Ritchie wedge, the translucent blocks of Elster and Joly and other means of comparing illumination intensities, all of which are simple and inexpensive of construction, but lack in sensibility and ease of comparison.

Other photometric devices will be found described in text books on photometry, but they do not merit serious consideration at this time, in most instances failing to equal those described in point of either accuracy, reliability or simplicity. Of these the flicker photometer is noteworthy. The difficulty in manipulating it and its inapplicability to electric lighting by alternating current make it unsuitable for use in illumination photometers.

Comparison Light Sources.—These are found in great variety in photometric work. They may be classified broadly as flame sources and incandescent electric lamps. Among the flame sources two deserve special mention. The pentane lamp, the legal standard of light in Great Britain, is used largely by gas companies in laboratory practice as a primary standard of light. The Hefner amyl-acetate lamp,

the legal standard of light in Germany, is used largely in Germany as a primary standard of light, and is used somewhat in this country in both laboratory and portable photometers. In addition, kerosene, benzine and gas burners have been used in photometers as secondary standards of light. The pentane and Hefner lamps as primary light standards give results of considerable precision when used in the laboratory, under carefully controlled conditions, and manipulated by those who are expert in their use. In common with the other flame sources used as secondary standards in portable photometers, but little in the way of precision and reliability can be expected. They are all so dependent upon uniform conditions of burning as to be unreliable when used where they are moved about the room, or where they are liable to changes in atmospheric conditions and in drafts. The fire risk which they entail is a strong objection to their use. The only place which they should have in the measurement of illumination is in connection with photometric apparatus which lays no claim to high precision, and in which simplicity of construction, absence of measuring instruments and source of energy supply, constitute an advantage which overbalances the superior accuracy obtainable with the incandescent electric lamp properly used. Such a field flame sources undoubtedly fill, offering a means of determination considerably superior to that obtainable with photometers based upon the visual acuity method.

With the incandescent lamp used as a secondary standard of candle power, most favorable photometric conditions may be obtained. Its use, however, necessitates a source of current supply and a means of determining with fair precision the voltage at which it burns, or the current which it consumes. Under these conditions it may be relied upon to remain constant for a limited period, during which time it constitutes the most reliable, accurate and satisfactory comparison light source.

Means of Varying the Intensity of Illumination Produced upon the Photometric Device by the Comparison Light Source.—This has been accomplished by a variety of methods, some of considerable ingenuity. These may be classified as follows:

First, variation in distance, applying the inverse square law; second, rotating disks, relying upon Talbot's law; third, inclination of an illuminated surface, applying Lambert's law of the cosine; fourth, variation of the intensity of the comparison light source; fifth, the use of absorbing media; sixth, the use of variable diaphragms, generally with diffusing screens; seventh, dispersion lenses; eighth, polarization method.

Of the above, the variable distance method is, in the opinion of the writer, superior in that it possesses accuracy, reliability, ease of verification, calibration according to a known law, simplicity, a wide range and universal applicability. No other one method possesses all of these advantages.

The properties of the rotating sectored disk have been investigated on a number of occasions, perhaps most recently by Dr. E. P. Hyde. This is an excellent means of varying the intensity of light, but lacks somewhat in simplicity where it alone is relied upon. It is possible that under some conditions errors might be introduced by this method when applied to alternating current electric lighting, and to some other forms of lighting in which periodical flickering phenomena are encountered.

The variation of the inclination of a plane with reference to the light incident upon it, or to the angle at which it is viewed, is an unsatisfactory method; first, because unless a perfect diffusing surface is obtained, the cosine law will not apply, and the instrument should be calibrated empirically; second, because any surface which approximates a perfect diffusing surface is likely to change in character, which would introduce an error into the scale calibration of the instrument; and third, because the scale calibration of an instrument in which this is used becomes very narrow with low intensities, so that the slightest displacement of the plane will produce a marked difference in the illumination in the region where the photometric comparison is rendered difficult because of the low intensity which is being studied.

Two methods of varying the intensity of the comparison light source have been used; in the one, adjustable opaque screens expose a greater or lesser portion of the luminous body. This method is particularly applicable when flame comparison sources are used. The other method consists in varying the intensity of the source itself—with flame sources, by wick adjustment, and with electric lamps, by varying the current flow. This method is unsuitable for use with flame sources, because it is necessary to wait some time after an adjustment is made, before a constant luminous intensity is obtained. With electric lamps it is objectionable because the satisfactory range throughout which the method may be applied is of necessity small, since with very low intensities the color value becomes altogether objectionable, and with higher intensities the lamp must be operated at so high an efficiency as to endanger its constancy.

Absorbing media offer an excellent and very practicable means of varying the light intensity, but must be selected carefully in order to guard against errors due to selective absorption. Properly selected, they form an excellent adjunct to a photometric system. If, however, they have any marked tendency toward selective absorption, they must be used very intelligently, or errors will be introduced. While it is possible to construct absorbing screens which may constitute a complete device for varying the intensity, yet this method has found its best application in varying the intensity by large steps where supplementary means are provided for effecting finer variations.

The comments in the previous paragraph apply as well to the use of absorbing screens with variable diaphragms.

Dispersion and polarization methods are but little used in this country in photometry of the class now under discussion. The writer has had no experience with these methods, but since obviously superior and more practicable means are available they would seem to merit but little consideration.

The Test Plate.—In general work the intensity of the light incident upon a given surface is the only quantity which it is practicable or even desirable to measure. This is not proportional necessarily to the illuminating effect, which varies as well with the point from which the surface is viewed, with the color of the light and with the color and character of the surface.

The criterion by which the light intensity is judged must be strictly proportional to the light incident upon the test plate, and must be independent of each of the other improper variables just mentioned, if the results of the observation are to show the intensity of the light incident upon the surface.

Whether or not the light falling upon the photometric device varies only with that incident upon the test plate, depends upon the design and location of that plate. Consequently there is no feature of an illumination photometer more deserving of the attention of its designer. But, strange to say, in this particular, many instruments are badly designed and liable to large error.

The requirements for a theoretically correct test plate are:

1. A plane white surface which, when viewed from the point of photometric observation, obeys Lambert's law of the cosines with reference to intensity of illumination produced by light incident upon its surface at any inclination and from any direction.
2. A material which will not introduce errors due to color differences.
3. A plate which may be placed at any angle.
4. A location such that neither the body of the observer nor instrument parts shall obstruct light which would otherwise fall upon the plate.

The character of the surface upon which the effect is studied naturally influences the results materially. If it were to consist of a mirror in which practically all of the reflection is regular, the value assigned to any light incident upon its surface would vary from 0 to 100 per cent. depending upon whether it was viewed from a point within or without the field of regular reflection. If the surface were glazed, light incident upon it at angles of sharp inclination would suffer or profit unduly through regular reflection, the nature of the effect depending upon the point from which the surface is viewed. Hence it is necessary to secure a plane surface which shall be as nearly as possible a perfect diffuser of light, in order that light incident upon it at any angle may be credited with its true intensity, and only its true intensity. Unfortunately there is no available surface which accurately meets these requirements. Therefore, in selecting a surface, the requirements must be kept in view as an ideal, and must be approximated as closely as may be possible.

Until it shall be found possible to use a true diffusing surface, results must vary with the direction from which the test plate is viewed, unless it is studied by reflected light from a point directly above the center of the plate, or by transmitted light from a point directly beneath the center of the plate. The first is obviously impossible, because it would necessitate interference with light which would otherwise fall upon the test plate. It follows, therefore, that the correct method is to consider transmitted light from a point directly beneath the test plate.

It is, of course, desirable to measure all of the light which would be incident upon an object at the point to be considered. In all interior lighting systems there is more or less diffused light, all of which has some illuminating value. In order to measure all of the

effective light, there must be no objective interference with light incident upon the plate at any angle. This means that all instrument parts, as well as the observer, must be beneath or behind the surface of the test plate. This is possible only when transmitted light, instead of reflected light, is measured.

The illuminating effect of any lighting installation may be a function of the horizontal, vertical or normal illumination produced, while a study of the illumination produced upon surfaces otherwise inclined adds data of value and interest to any investigation. The necessity for providing simple means for placing the test plane at any desired angle is therefore apparent.

The introduction of differences in color values complicates photometry seriously. If the light from the mercury vapor lamp were to be studied upon a red surface, its illuminating effect would be no criterion of the light intensity. Hence the only color which is practicable is white, of as great purity as may be obtainable and as free as possible from selective absorption. With such a test plate, lights of different colors are credited with approximately their true intensities, when the test plate is viewed from the photometric device.

The Ideal Photometer.—It appears, therefore, that in building a photometer, the designer has a choice of many photometric devices, comparison light sources and means of varying the light intensity and effecting the photometric comparison. With respect to the test plate there should be no choice. It should have a plain white diffusing surface; it should be translucent and viewed from directly beneath its center; it should be capable of location at any angle, and should be so located that all instrument parts and the observer are beneath or behind it.

In the ideal photometer such a test plate would be found combined with the most sensitive photometric device, the most reliable comparison light source and the best means of varying the intensity. These features should receive first consideration, for reasonable precision ought to be the first desideratum. Next in importance comes portability, simplicity of operation and reasonable cost. If there were any necessity for sacrificing reasonable precision in order to secure other desirable qualities, some compromise might seem advisable, but since this is not the case there can be no objection to adherence to the ideal, as set forth above.

As there is an insistent demand for an illumination photometer which shall be both reasonably accurate and thoroughly practicable, it is felt that a discussion of the instruments which have been designed with this in view will be of interest to the membership of this Society. In the following paragraphs will be found brief illustrated descriptions of 11 photometers. Only the essential features of each are touched upon. The cuts are lettered similarly in order to facilitate comparison. Thus *A* indicates the test plate, *B* the photometric device, *C* the comparison lamp and *D* the means of varying the intensity.

Illumination Photometer, Designed by Walter Beckstein.—Fig. 1

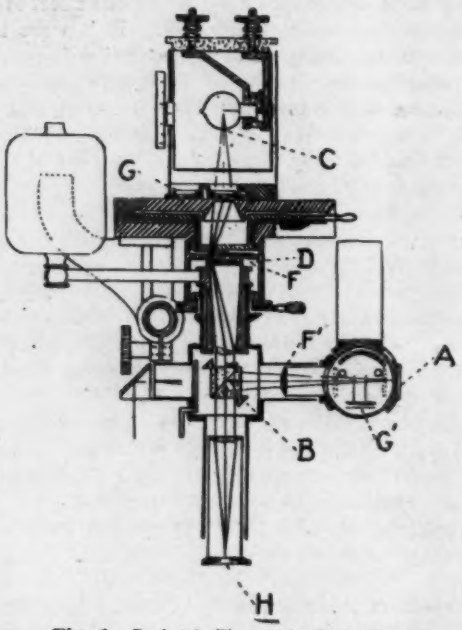

Fig. 1.—Beckstein Photometer Sector Type.

shows a plan of the photometer. The test plate *A* is placed at the point where it is desired to study the illumination. This plate may be rotated throughout a vertical plane about the photometric device *B* as an axis. *B* is a Lummer-Brodhun cube through which the lower surface of test plate *A* is viewed. Through the prisms *B* may be viewed also translucent plate *G*, which is illuminated by the comparison lamp *C*. Equality of illumination is obtained by viewing the plate *G* through a portion of lenses *F* which may be rotated. At position *D* is placed a variable sector disk about the axis of which the beam of light is rotated by the lenses *F*. The result of the photometric setting is obtained from the size of opening of sector disk *D*, which is necessary in order to obtain quality of illumination. This device is in effect a rotating sector disk except that the beam of light instead of the sector is rotated, thereby facilitating precise adjustment of the sector disk.

Illumination Photometer, Designed by Walter Beckstein.—This photometer, of which a plan is shown in Fig. 2, is a modification of

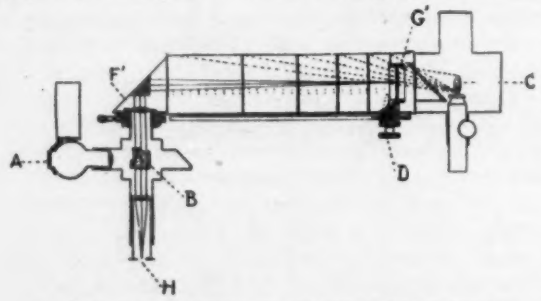

Fig. 2.—Beckstein's Form of Weber Photometer.

the Weber photometer and simpler in construction and less costly than the photometer described in the preceding paragraph. The test plate and prism arrangement are similar, but the comparison lamp *C* is a benzine lamp, and equality of illumination is obtained by movement of translucent screen *G* by means of rack and pinion device *D* along a tube, its intensity of illumination varying as the square of the distance from lamp *C*. Results of photometric settings are read off directly from a scale along the tube through which plate *G'* travels.

Illumination Photometer, Designed by Prof. Andre Blondel and Broca.—Fig. 3 shows a plan of the photometer. That portion of the

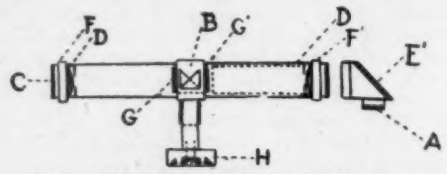

Fig. 3.—Blondel and Broca's Photometer.

light which is transmitted through test plate *A* is reflected from the 45° mirror *E'* through lens *F'* upon ground glass plate *G'* (which forms part of the photometric device). Before lens *F'* is placed "cat's-eye" diaphragm *D'*. A comparison light source *C* which is not described is placed to the left of the apparatus. Its light passes through lens *F* and falls upon ground glass *G*. This is varied in intensity by the adjustable "cat's-eye" diaphragm *D*. The photometric device *B* consists of crossed prisms through which ground glass plates *G* and *G'* are viewed from the binocular arrangement *H*. Equality of illumination is produced by adjustment of variable diaphragms *D* and *D'*, which are equipped with means for indicating the size of the aperture.

Illuminating Power Photometer, Designed by Douglas Burnett.—A vertical section is shown in Fig. 4. The light which is to be studied

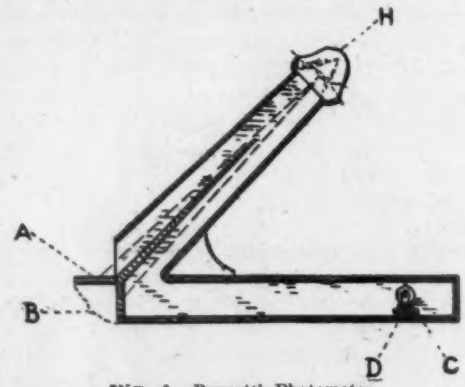

Fig. 4.—Burnett's Photometer.

falls upon test plate *A*, which is one surface of a photometric wedge. The other surface of the wedge is illuminated by comparison lamp *C*,

which travels along the horizontal axis of the box. This lamp is moved by means of a handle *D*, which protrudes through the side of the box. The two surfaces of the wedge which constitutes the photometric device *B* are viewed from position *H* through a box which is divided by a partition which constitutes a well-defined line of separation between the two surfaces of the wedge. Results are indicated on a scale along the horizontal box which is calibrated directly in foot-candles.

"*Luminometer.*" *Designed by J. T. Marshall.*—Fig 5 shows the ar-

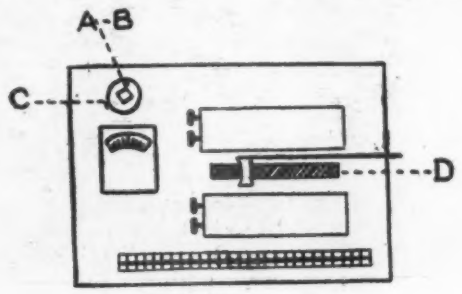

Fig. 5.—Marshall's Photometer.

rangement of the instrument. The test plate *A* is also the upper surface of the photometric device *B*. This consists of a screen of which the translucency is varied by different thicknesses of paper. It is illuminated from beneath by the comparison electric lamp *C*, the intensity of whose light is varied by means of rheostat *D*. Lamp *C* is operated from two dry cells within the instrument, a spring switch being placed in the circuit so that the lamp is operated for a minimum time only. To effect a photometric setting, the flow of current through lamp *C* is varied until disappearance of contrast is obtained at screen *B* when viewed from above at an angle of about 45° to its surface. The resistance of lamp *C* is then measured by means of a simple Wheatstone bridge with a portable galvanometer, both inclosed within the instrument. One arm of this bridge consists of an exposed wire, stretched taut. Beneath this wire is placed a millimeter scale. The contact is moved along the exposed wire until the point of no deflection is obtained, and the foot-candles value is then obtained from the scale reading through an interpretation curve.

Illumination Photometer, Designed by Martens.—Fig. 6 shows a

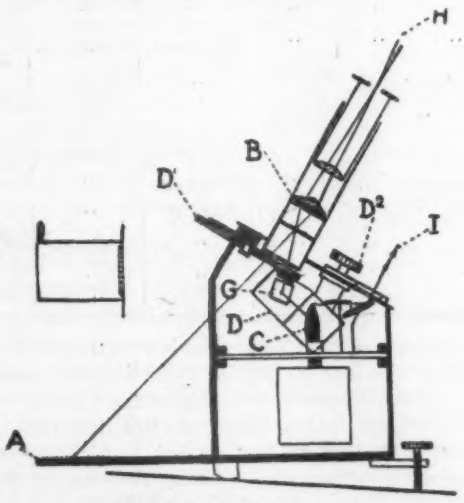

Fig. 6.—Marten's Photometer.

vertical section through the instrument. Test plate *A* which receives the light to be studied is observed through the photometric device *B*, through which may be seen also the surface of plate *G* which is illuminated by comparison benzine lamp *C* through a pair of sliding mirrors *D*. These mirrors vary the distance between lamp *C* and plate *G*, being operated from rack and pinion device D^2. Results are read directly from a scale over which plays a pointer attached to D^2.

Illumination Photometer, a Modified Design of the Mascart Photometer.—In Fig. 7 the light to be studied falls upon translucent paper

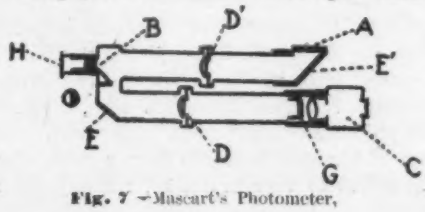

Fig. 7.—Mascart's Photometer.

A, which constitutes the test plate. That which is transmitted passes through the 45° mirror *E'*, a convex lens, and falls upon the upper half of translucent screen *B*. A comparison lamp *C* illuminates translucent screen *G*. Light which is transmitted through this screen passes through a convex lens, the 45° mirror *E*, the total reflecting prism immediately above *E*, and falls upon the lower part of screen *B*, where it is viewed from position *H*. Both lenses mentioned have adjustable diaphragms *D* and *D*, which are used to vary the intensity and effect equality of illumination upon screen *B*. The adjustment of these diaphragms indicates the result of the photometric settings. Comparison lamp *C* is a flat flame gasoline lamp. The instrument is standardized by a Carcel lamp whose light falls upon the test plate.

Illuminating Power Photometer, Designed by Sir William Preece and A. P. Trotter.—Fig. 8 shows a vertical section through the in-

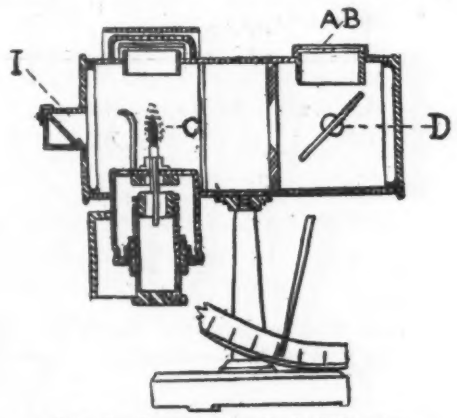

Fig. 8.—Preece and Trotter's Photometer.

strument. The light to be studied falls upon surface *A*, which is also a portion of the photometric device *B*. The comparison lamp *C* illuminates Bristol board *D*, which may be inclined at any desired angle. Through slits in surface *A*, portions of screen *D* may be viewed. Photometric balance is made by equalizing the brightness of surfaces *A* and *D*.

"*Candle-Foot Photometer,*" *Designed by W. D'A. Ryan.*—In Fig. 9 the light to be studied falls at *A* upon one surface of the photometric

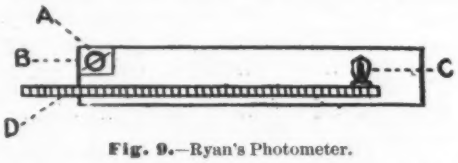

Fig. 9.—Ryan's Photometer.

device *B*, which consists of a translucent block, divided diagonally by a thin, opaque film. The comparison electric lamp *C* illuminates the other half of the block. The distance between this lamp and the block is varied by means of rod *D*, upon which is calibrated a scale which indicates the results of photometric settings. The photometric device *B* is viewed through the side, equal portions of the two halves of the block being viewed.

Weber Photometer.—In Fig. 10 the light to be studied is received

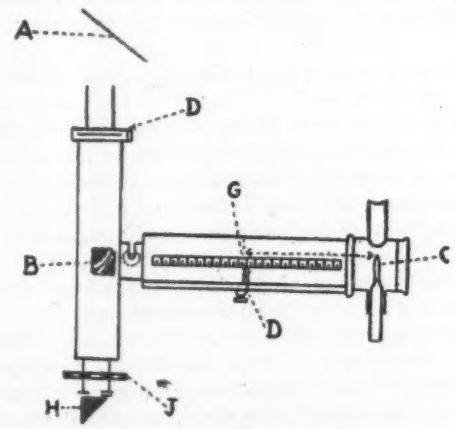

Fig. 10.—Weber Photometer.

upon the portable test plate *A*, which consists of white cardboard. This is viewed from eyepiece *H* through a simple Lummer-Brodhun cube *B*. The light from the comparison benzine lamp *C* illuminates a traveling translucent screen *G*, which is viewed from the eyepiece *H* through *B*. A unique feature is the use of colored glasses in the ocular tube with a view to comparing illuminants of different color

values with respect to those qualities upon which depends the ability of the eye to perceive objects which they illuminate. As has been stated, this is not necessarily proportional to the intensity of illumination.

Weber Photometer—Modified Portable Form.—The Weber photometer is now made in a more portable form, and with some modifications. A vertical section of this instrument is illustrated in Fig. 11. The

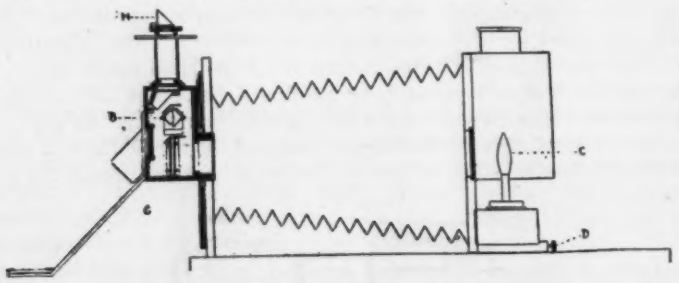

Fig. 11.—Portable Form of Weber Photometer.

test plate *A* bears a fixed relation to the photometric device *B*, but may be placed at any angle in a vertical plane, the photometric device moving with it around the horizontal axis of the comparison Hefner lamp. Equality of illumination is obtained by moving the comparison lamp *C* along the photometric axis. Results appear in terms of a unit of illumination intensity. The range is increased by means of absorbing screens.

The accompanying tabulation shows the character of the essential features of each of the photometers described in the preceding paragraphs:

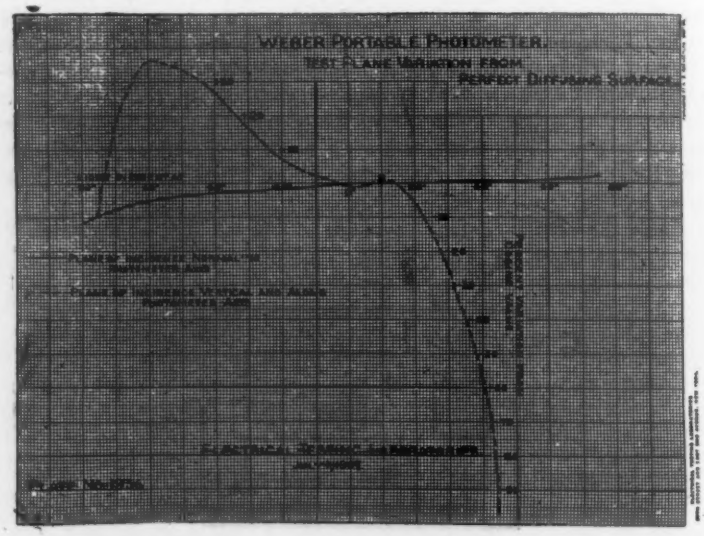

Fig. 12.—Curves Showing Errors Due to Improper Location of Test Plate.

It was found that in one of the instruments in which a flame source was used, readings could not be relied upon within 5 per cent. because of flame variations due to drafts, changes in humidity, etc.

In measuring diffuse illumination, where much of the light comes from the ceiling and walls, it was found that with two of these instruments in which the design and location of the test plate were incorrect, results were obtained which were too low by 20 and 29 per cent. respectively. This was due to regular reflection and obstruction of light by the body of the observer or by instrument parts. With the same instruments, change from a black coat to a light coat on the observer, introduced differences amounting to 10 and 18 per cent. The extent of these errors illustrates the necessity for careful design and location of test plate. It is hardly worth while building a photometer which is liable to errors of this character, in addition to any others which may be entailed by the use of improper comparison light sources, low sensibility photometric arrangements, and errors in varying the intensity of the light from the comparison light sources.

Table Showing the Character of the Essential Features of each of the Photometers Described in the Preceding Paragraphs.

Photometer.	Photometric Device.	Comparison Source.	Variable by which Setting is Made.	Test Plate				Method of Use.
				May be Placed.	Color.	View Point.	Location, with Ref. to Inst. Parts.	
Beckstein { Sector type. }	High sensibility.	Electric lamp.	Sectored disk.	At any angle.	White.	Correct.	Correct.	Not stated.
Beckstein { Weber type. }	" "	Benzine lamp.	Distance.	" "	"	"	"	"
Blondel and Broca....	Low sensibility.	Not described.	Diaphragms.	" "	"	"	"	
Burnett.....	" "	Electric lamp.	Distance.	" "	"	Incorrect.	Incorrect.	Substitution Method.
Marshall.....	" "	" "	Current.	Horizontally.	Pinkish White.	"	Correct.	Direct Comparison
Martens.....	High sensibility.	Benzine lamp.	Distance.	"	White.	"	Incorrect.	
Mascart (modified)....	Low "	Not described.	Diaphragms.	At any angle.	"	Correct.	Correct.	Substitution Method.
Preece-Trotter.....	" "	Amyl-acetate lamp.	Inclined surface.	Horizontally.	"	Incorrect.	"	
Ryan.....	" "	Electric lamp.	Distance.	Horizontally or Vertically.	"	"	"	
Weber.....	High "	Benzine lamp.	"	At any angle.	"	"	Incorrect.	
Weber—portable.....	" "	Amyl-acetate lamp.	"	" "	"	"	"	Direct Comparison

A study of this table will show that no one of the instruments conforms in all particulars to the requirements for an illumination photometer.

Fig. 12 illustrates the errors due to the improper location of the test plate.

As an example, the Martens photometer incorporates many good features, but its designer has largely destroyed its usefulness by giving the test plate an impossible location where the measurement of the total illumination produced in any diffused lighting system is entirely out of the question because the instrument itself obstructs so much of the light.

It was hoped that a number of the instruments could be obtained for investigation, but some of them are more or less in the experimental stage and their designers were not in a position to offer them for this purpose; however, two of the instruments were tested. The results obtained will illustrate the extent of errors which may be encountered in measuring illumination with instruments which are incorrectly designed.

As respects the sensibility of the photometric device it was found from repeated settings with one of the instruments in which the photometric device is of low sensibility, that no higher accuracy than 6 per cent. could be obtained. The maximum variations in settings with this instrument were 15 per cent. below, and 10 per cent. above the average.

Note.—Generally speaking, European instruments, as illustrated in the Beckstein, Blondel and Broca, Martens, Mascart, Preece-Trotter and Weber photometers, differ from American instruments as designed by Burnett, Marshall and Ryan, in that they are designed more particularly with regard to theoretical requirements than with regard to the utmost simplicity of operation and lowest cost. Many of the European instruments are relatively complicated, being combinations of a large number of parts, many of which would appear to the American mind as unnecessary.

As an illustration of the possibilities of errors entailed by reliance upon the direct comparison method in which a standard lamp is used directly in comparison with the test source, it was found that, with one of the instruments, 7 skilled observers who, however, were not familiar with the particular instrument under test, obtained values which varied from 21 per cent. below to 34 per cent. above the value which was considered to be representative, namely, the mean of the

results of the 7 observers. The average variations of these observers from such mean was 13 per cent.

While it is unlikely that there should be incorporated in any one instrument all of the bad features referred to, yet all of the photometers listed above fail to meet theoretical requirements in one or more particulars. The errors found in some of the models are, therefore, listed in the following tabulation for reference:

Extent of Errors Due to Improper Design or Use of Illumination Photometers as Judged by Errors Found in Certain Models.

Photometric device of low sensibility	6 to 10 per cent.
Flame source as comparison lamp	3 to 5 "
Direct comparison method neglecting personal equation	13 to 34 "
Improper design and location of test plate when measuring diffuse illumination	20 to 29 "

The Use of Illumination Photometers.—In the measurement of illumination, either of two general methods may be followed. The first is the direct comparison method in which a primary standard of light is used, or a secondary standard of light is used as a primary standard, so far as the instrument is concerned. The Hefner lamp, more than any other light source, is used in this way. Or an incandescent electric lamp may be standardized to yield a certain candle power and may be used, as is the Hefner lamp, for direct comparison purposes. Such a light source is located at a definite distance from the photometric device and is calculated to produce a fixed intensity upon that device. This method has the great advantage that it permits an instrument to be more nearly self-contained, and to be used without reference to any other light sources. However, it is liable to serious objections in that all changes in reflecting surfaces or transmitting screens and changes in the comparison lamp, as well as any misplacement of parts, are likely to introduce errors for which no compensation is made. Furthermore, the method makes no allowance for the personal equation. The second, and superior, method is commonly known as the substitution method. This covers a multitude of photometric sins. Here the comparison light is strictly secondary and is standardized and verified from time to time by other standards of light so placed as to produce upon the test plate illumination of known intensity. By this method changes which would introduce errors where the direct comparison method is used, are compensated for either entirely or in part, since every effect which they produce upon the measurement of light from a test lamp will be proportional to the effects produced upon measurements of unknown intensities.

It is very important that instruments used in measuring light from any illuminants should be calibrated with reference to light of known intensity from illuminants of similar character. It must be recognized that in many cases this is not practicable. Where it cannot be done, and particularly where the color values or characteristics of the light are widely different from those of the light sources with which the instrument was standardized, the possibility of error should be recognized.

An excellent method of determining the precision of the photometric part of an illumination photometer is to use it in the photometry of single light sources. The instrument designed specifically for the measurement of illumination differs from the laboratory instrument used to measure candle power only in that it is equipped with an illumination test plate and is generally rendered portable and so inclosed that it may be used in a brightly lighted room. Any illumination photometer may be used in a determination of the candle power of light sources if the proper precautions are taken. The light sources and the test plate of the instrument should be so screened that no light except the direct rays from the source under test reaches the test plate. In using an illumination photometer in this way, many large sources of error which attend the measurement of total illumination are eliminated, and it is possible to learn more definitely the degree of precision obtainable with the instrument used as a simple photometer.

One of the large difficulties in the practical use of an illumination photometer is to be found in the variability of light intensity in most commercial installations. If the installation consists of incandescent electric lamps, this can be dealt with best by operating the comparison electric lamp from the lighting circuit, when its variation will be similar in character, if not in degree, to that of the illumination to be studied. This is known as the "similar circuit method." When an instrument is so designed that this cannot be done, or when the lighting installation consists of other than incandescent electric lamps, it is advisable to continue observations at each test point over a sufficient period to afford a fair average result.

With any of the photometers described in this paper it is probable that the skilled photometrist could approximately correct results, for he would locate the sources of error, determine their extent and apply such corrections as were possible. Most errors in photometry are occasioned by failure to recognize the limitations of instruments used. Recently there has been exhibited a tendency to forget that photometry is a science, and that one may become skilled in its practice only after he has acquired a knowledge of the fundamental principles involved, and has become experienced in the application of those principles. Instruments have been designed which apparently make so little demand for technical skill on the part of the observer as to give rise to the belief that photometry is as simple as is their operation. This has led to the publication of results which would appear to be utterly unreliable, judging from the instruments and methods employed in making the tests. Recent files of the technical press and the *Transactions* of our Society offer testimony to this effect.

It is submitted that this Society, and illuminating engineers in general, must rigidly uphold the best traditions of the past in photometry, and must so apply recently acquired knowledge and experience that a still higher standard may be established. As the photometry of light sources and of illumination has an important place in illuminating engineering practice, we should oppose strongly the recent tendency which has already led to aspersions upon the accuracy of illumination measurements, and which, if followed, must surely bring illumination photometry into disrepute.

In closing, a few maxims are offered, which the illuminating engineer would do well to bring to bear upon photometric problems. If the points are not well taken, it is hoped that the fact will be brought out in discussion.

An instrument must be a good photometer before it can be a good illumination photometer.

Measurement of illumination is more difficult than the measurement of candle power.

In obtaining a photometric setting one does not necessarily determine the value of the light studied.

Every photometer is to be regarded with suspicion until its accuracy is demonstrated. It is then to be regarded with suspicion until it is shown that no change has occurred since verification.

No photometric information, is better than misleading photometric information.

A New Recording Gas Calorimeter.[1]

The changed conditions in the production and use of gas for illuminating, heating and power purposes which have come about during the past few years have caused attention to be directed to the methods employed for testing its quality. In the department of lighting, the introduction of the incandescent mantle has necessitated, as our readers are aware, the adoption of another standard than that of candle power for testing the gas employed with it; while for cooking stoves, heating appliances and gas engines, it is obviously of greater importance to have gas of a definite heating value than to have it of a particular light-giving power. It is consequently within the bounds of probability—indeed, there is marked evidence of it in existence—that in the not distant future gas will have to be supplied of a standard calorific value. This fact has led to the production of an instrument—the calorimeter—which will indicate this value clearly and accurately, and at the same time automatically. The calorimeters now in use are constructed mostly on the absorption principle—the heat developed by the burning gas being absorbed by water contained in a jacket surrounding the flame. If the quantity of gas burnt and the amount and temperature of the water used are known, the calorific value of the gas may be ascertained by calculation. Calorimeters working on this principle give a thermal value of the fuel tested which is not comparable with actual results in practice - being, in the case of some gases, considerably too high. For the new instrument about to be described, however (which is constructed by Messrs. C. H. & F. G. Beasley, of Smethwick), no water supply is required, and there is nothing of a complicated nature in its mechanism, nor are there any delicate parts liable to give trouble in the hands of unskilled people. The advantages of such a calorimeter should appeal to all who require continual gas testing, and are desirous of saving the expense of analyses. It is entirely automatic in action and self-contained; and it gives, it is said, clear permanent records of the calorific values of the gases tested.

The main idea of Messrs. Beasley has been to design a calorimeter of which the indications should be a valuable guide to an engineer by not representing the total number of heat units actually generated by the burning (in air) of a unit weight or volume of a gas, but only

1. *Journal of Gas Lighting.*

the number available for practical purposes. When a gas containing free or combined hydrogen burns, water is formed: and if this escapes from a gas engine or any other appliance in the state of vapor, a considerable percentage of the total heat of combustion of the gas is lost. It is apparent, there-

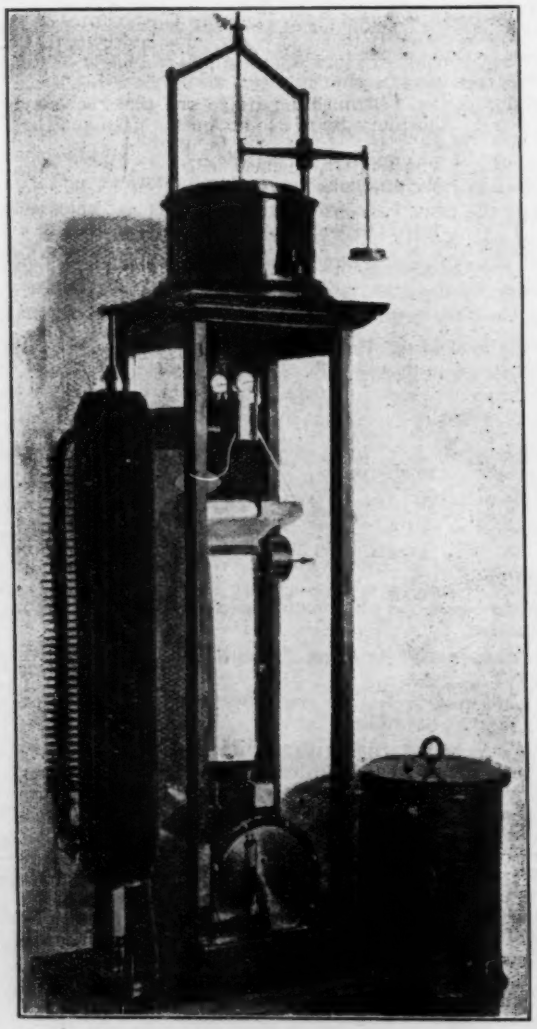

Fig. 1.—The Beasley Calorimeter.

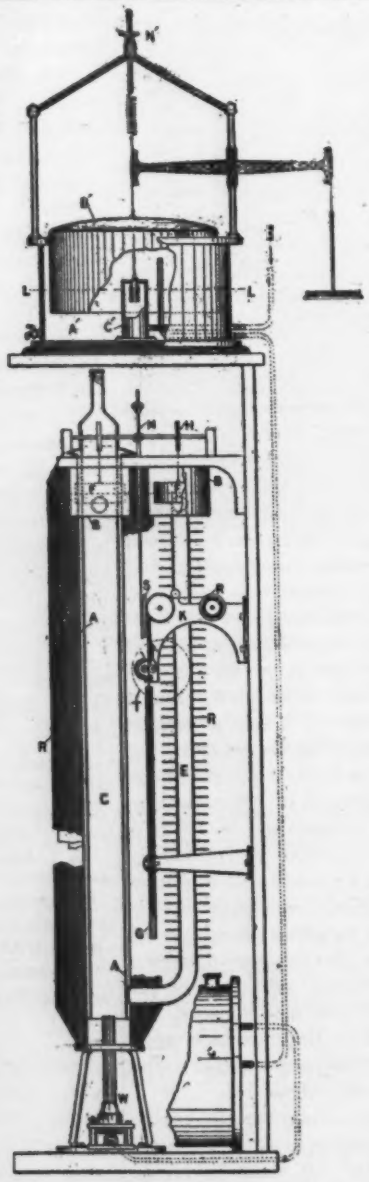

Fig. 2.—Section of Calorimeter.

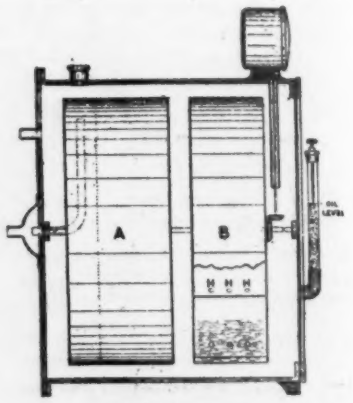

Fig. 3.—Gas Controller.

Fig. 4.—Atmospheric Burner.

fore, that of two gases having the same total heats of combustion, the richer, from a practical standpoint, is the one containing the least hydrogen. A gas composed of equal quantities of hydrogen and carbonic oxide has a high value calorific power of 344, and a low value one of 319. But supposing the composition of the gas to change to 75 per cent. of hydrogen and 25 per cent. of carbonic oxide, the high and low values would alter respectively to 344 and 307.

A calorimeter recording high powers would indicate practically no change in the quality of the gas, notwithstanding the fact that the general behavior of gas appliances and the outputs of gas engines would fall off considerably. While these may be somewhat extravagant examples, they nevertheless serve the purpose of demonstrating the importance of having an instrument which records the low and not the high values for the calorific powers of gases. In water cooled calorimeters, the products are brought down to the temperature of the air by a stream of water; the rise in temperature of the water being a measure of the calorific power of the gas. In the Beasley calorimeter, the gas is burned in a good supply of air in a well-radiated chimney, the average temperature rise of which is directly proportional to the heat developed by the flame. And since the products of combustion leave the instrument at about 70° C., no water is condensed; and by virtue of this the calorimeter gives only the low value powers.

The new calorimeter is shown in the accompanying illustrations, Fig. 1 being a perspective view and Fig. 2 a sectional diagram. A U-shaped vessel, one limb of which is formed by the annular space *A*, between the concentric walls of a vertical chimney *C*, is provided at the top of each limb with a small tank *B*, and contains enough oil to fill the tube *A* (which is a jacket surrounding the chimney) and the cold limb *E*, and also to partly fill the two tanks *B*. The gas to be examined is burned at an atmospheric burner *W* at the bottom of the chimney, and the oil in the heated limb *A* rises to a level above that in the cold limb corresponding to the increased temperature. The difference of level is, therefore, a measure of the calorific value of the gas, and is recorded automatically by means of two floats *F*, situated in the tanks , and connected by threads to two pulley wheels arranged upon a horizontal spindle *H*. This spindle rotates as the floats rise and fall respectively, and operates a lever *M* carrying a marker. The latter traces a diagram upon the moving band of paper actuated by the clockwork *T*, and ruled with a scale which indicates the low calorific values. The paper gear is shown built upon the bracket *K* The supply for a week's run is wound on a wooden spool and is transferred for use to the roller *P*. By means of the clockwork the paper is drawn over rollers passing the back of the scale *S* in contact with the marking pen *M* to the long paper guide *G*, which is sufficiently long to always allow the exhibition of a 24 hours' record.

To secure the constant stream of gas to the calorimeter, it has been necessary to use a pressure regulator and a stream controller, for which a patent has been applied for. The pressure regulator (shown above the calorimeter) is of the ordinary type; but the dimensions and weights of the different parts have been carefully studied, so as to meet present requirements. The outer vessel A^1 is filled with oil to the level *L*, and forms a lute to the bell B^1, from the center of which is suspended by a light chain a somewhat heavy cone. For normal gas pressures the bell is counterpoised by a spring and balance weight *D*. An increase or decrease in the pressure raises or lowers the bell, restricting or opening the gas passage between the suspended cone and a feather-edged seating in the chamber C^1. The bell, being large, is very sensitive to small changes of pressure, and the regulator will maintain in the bell a constant pressure of 5-tenths of an inch of

water, which is the pressure necessary to work the controller, and this against pressure variations from 1 inch to 10 inches in the main gas supply. This form of regulator has been tested and found to behave perfectly, even when the cone and seating are almost covered with tarry matter from producer gas.

The flow of gas through a pipe or orifice depends directly upon the square root of the actuating pressure and the area of the orifice. To obtain a constant stream of gas, therefore, it is not only essential to have a constant gas pressure, but also a constant resistance to the flow of gas. The constancy of the resistance offered to a stream of gas by the jet of an ordinary burner cannot be depended upon, particularly in cases where the gases are not clean; and on this account it has been necessary to design a special form of controlling apparatus, shown in Fig. 3, which regulates the flow of gas independently of the burner jet. The principle of this controlling apparatus is the regulation of the delivery of the gas by maintaining a constant speed for the drum of a gas meter.

The meter drum *A* is directly coupled to the controlling drum *B*, which is divided into 6 or more compartments, and contains a definite quantity of rectified paraffine. The flowing of the paraffine from compartment to compartment through the small holes *H* constitutes a definite brake in the rotation of the drum system; and, actuated by pressure maintained constant by the pressure regulator, the meter drum is turned at a constant speed and delivers a uniform stream of gas.

Since the magnitude of the gas stream is independent of the size of the burner jet, the latter is made unusually large, and much tarry matter may deposit itself in the jet without in the least affecting the constancy of the gas stream. The atmospheric burner used in connection with the calorimeter is shown in Fig. 4. The air inlet is easily adjusted by the large milled screw, and a special feature of the burner is its construction for readily allowing the removal of a dirty gas jet and its replacement by a spare clean one. The steatite rosehead shown in the illustration has been dispensed with in the latest type of burner.

Considerable attention has been given to the testing of the Beasley calorimeter, and the patentees claim that it is accurate, very sensitive and thoroughly reliable. A test was carried out in which commercial hydrogen from a cylinder was burnt under the calorimeter. By analysis, the gas was found to have a low value calorific power identical with that given by the calorimeter—viz., 274 B.T.U. per cubic foot. The hydrogen was diluted with different volumes of nitrogen, and the following tabulated results show the degree of sensitiveness of the instrument:

Stream of Gas in Cubic Feet per Hour.	Percentage Composition of the Mixed Gases.		Calorific Values.	
	Commercial Hydrogen.	Nitrogen.	Deduced from Composition.	Recorded by Calorimeter.
5.18	100.00		274 B.T.U.	274 B.T.U.
5.18	98.99	1.01	271 "	271 "
5.18	97.30	2.70	267 "	266 "
5.18	91.99	8.01	252 "	252 "
5.18	86.00	14.00	236 "	237 "

The calorimeter has also been tested and found to be very insensitive to normal changes—(*a*) in the temperature and humidity of the atmosphere, (*b*) in the condition of the radiators, and (*c*) to the state of the inside of the chimney. In one test made, the steady records of the calorific value of a homogeneous gas were not affected by as much as 1 per cent. by the settling of large quantities of dust on the radiators; nor were they in a second case by the abnormal coating of the inside of the chimney with soot from the burning of machine oil.

The gases used for standardizing the instrument are hydrogen and carbonic oxide—the latter gas being very convenient, as it can be prepared in a very pure state by decomposing formic acid with sulphuric acid. The gas is generated (in large flasks), washed with water and caustic soda, and then stored in a large gasholder. It is tested in the Hempel apparatus for carbonic acid (which should be absent), and also for oxygen, etc. But for the more particular estimation of the total carbonic oxide present in what should be practically pure gas, an apparatus has been specially designed, which gives very uniform results, as shown by the following analyses of two samples: No. 1, total CO = 98 per cent.; No. 2, total CO = 97.97 per cent. The calibration of the instrument is also checked by the use of pure hydrogen.

The calorimeter described is finished in polished slate and mahogany, stands about 7 feet high, occupies a floor space of approximately 3 square feet, and weighs about 2 cwt.

Priming Coats for Metal Surfaces: Linseed Oil vs. Paint.

By Mr. F. P. Cheesman, M. Am. Soc. for Testing Materials.

Previous to 1885 it was almost a universal custom to use boiled linseed oil as a shop or priming coat for metal. At the present time very few bridge engineers specify the use of boiled oil. Yet there are enough still doing so as to make it worth the effort to call their attention to the fact that they are making a mistake and inviting corrosion by so specifying.

I will not attempt to go into the chemistry of linseed oil, the fact being that we know less about linseed oil than probably any other oil used in the manufacturing trade. This is due largely to the fact that we cannot get a recognized standard for linseed oil, owing to the great changes which take place in the article itself. The yield of oil from year to year varies from 22 per cent. to 34 per cent. from North American seeds, while it has been known to go as high as 40 per cent. in foreign seeds; the percentage of water ranges from 6 per cent. to 10½ per cent. For the paint trade the quality of the oil is measured by its power of absorbing oxygen, and, rated by that standard, Baltic seed is No. 1; Bombay, Calcutta and Black Sea seed No. 2; North American seed No. 3 (although there is quite a difference in the values of North American seed, Dakota seed making better oil than Missouri seed, and seed from new soil better oil than from old soil on which fertilizers have been used), and Argentine seed No. 4, or poorest. The quality of the seed does not seem to depend upon climatic conditions so much as upon the quality of the soil.

At a meeting in 1906 of the New York Section of the Society of Chemical Industry, Dr. A. H. Sabin in an article on "The Oxidation of Linseed Oil," showed that after the same oil had been placed in 6 glass flasks connected together with tubing and allowed to stand in a well lighted room there was such a difference in the weight after drying that one had gained 2½ times as much as the other, the respective figures being 10.1 per cent. and 25.5 per cent. gain. Dr. P. C. McIlhiney at the same meeting said, with regard to the atmospheric oxidation of linseed oil, he had himself found that the same sample of linseed oil would at different times, and under conditions that were apparently the same, absorb very different percentages of oxygen, or at least that the increase of weight on drying was very different. I mention the above to show why it is possible to have conflicting results when the paint maker has made no change in his vehicle. Linseed oil is to-day the best paint vehicle we know of, but it contains some of the still unknown mysteries of nature and it occasionally gives us a knockout blow.

Several very interesting facts were stated by practical men at the third annual convention of the Maintenance-Of-Way Master Painters' Association of the United States and Canada, held in New York, November 13 and 14, 1906, and are printed in their proceedings. Mr. J. W. Houser (Cumberland Valley R. R.), President of the Master Car and Locomotive Painters' Association, stated the following experiences:

We have another bridge crossing the Potomac river; I do not recall just when that was painted—perhaps in 1892. That came to us with a coating of boiled oil and we have had quite a good deal of trouble with it. I do not like to see a coating of boiled oil on a bridge; I would rather have it a little rusty than with this shop coating of oil. I believe we can take care of rust before the bridge is painted better than we can after it has this shop coating; it seems to hold the blue scale for a little while, but will finally give way. We had the same trouble on a bridge at Martinsburg, although we tried to clean it the best we could. I think if the shop coat of boiled oil had been left off we would have had no trouble. I do not know what experience you have had, but this has been mine—on new work, of course. Old work we have to take care of as everybody else does; we scrape it where necessary, and as a rule give two coats of paint. But I would like to know if the experience of others with boiled oil has been the same as mine.

Mr. H. J. Barkley (Ills. Central R. R.) said:

We have had the same experience. We had 50 sets of plate girders come to us with a shop coating of boiled oil (I suppose it was given so as not to cover up the shop mark), and we had similar experience with them; a wire brush had no effect on the oil. They have been in use for 5 or 6 years, and are in a terrible shape. We could not get off the blue scale and rust when they were first painted.

Mr. J. H. Cummin (Long Island R. R.) said that he did not think we can lay that to the manufacturers of steel work. The engineers specify how the steel is to come from the works; some specify a coat of boiled oil, some a coat of red lead. So you want to get back at the engineers, not the manufacturers. The writer in the course of his remarks made the following statements:

Any practical master painter will allow that boiled linseed oil

when used alone for the first coat on metal will not dry hard in weeks. It oxidizes on the surface, absorbing moisture and forming a skin, leaving the underneath portion soft and easily knocked off in shipping, and later on will cause subsequent coats of paint to crack and peel. This is because the first coat of oil must dry some time, and in doing so will force the top coats to crack, and sooner or later come off.

Mr. Emil Gerber, M. Am. C. E., in his report on the Illinois Central R. R. bridge at Cairo, Ills., shows that the approaches, which received one shop coat of paint, weathered better than the bridge, which received one shop coat of oil. When the Cumberland Valley R. R. bridge at Harrisburg, Pa., was built in 1887, it was built jointly by the Edge Moor and the Union Bridge Works, and one applied shop coat of paint and the other a shop coat of oil. After erection it was found that the oiled part of it was rusting very badly. Two coats of our paint were soon applied on the entire structure and the section that received one coat of paint at the shop stood much the better.

Mr. R. I. Sloan, late chief engineer of the South Side Elevated Railroad, Chicago, Ills., specified oil for the priming coat. He allowed the Lassig Bridge and Iron Works to paint the section that they built at their shops with one coat of oxide-of-iron paint, and the structure received two coats of our light colored paints. The section built by Lassig, covered with three coats of paint, weathered much the better.

We also quote from Mr. M. P. Wood's book on "Rustless Coatings:"

Many engineers advocate the use of boiled oil alone for the first or priming coat, applied either at the rolling mill to protect the metal during its transit from the mill to the construction shop, or at the shop when ready to ship for erection. The general reason assigned for this practice is that the boiled oil "soaks into the scale and dries and prevents further tendency toward corrosion."

This theory is absolutely without proof, from any standpoint. How far any oil or liquid can soak into iron or steel or the still harder mill scale that forms on these metals, these Solons do not state. The use of such oil coatings is, in general, to conceal some slop work on the part of the inspector, or constructor, at an earlier stage of the work than would be possible later on. However consistent and beneficial the first coating of oil may be for a wood or masonry surface, it has no place on a metallic one, when applied for the correction of the mill scale evil. No number of these oil or even paint coatings will soak into and bond these scales together, or to the metal surface. There are hundreds of records of the painting of important railway structures, where the "first coat of boiled oil" method was used, and, in the great majority of instances, the utter and rapid failure of the coating, and the extra corrosion of the structure, could be directly assigned to this so-called method of protection. The weather resisting power of an oil coating is almost nil compared with that of a paint. If the advocates of oil coatings are so sure of its benefits as against a paint, why not make all the coatings of oil alone, no matter what it covers, a wire or an anchor? It will soak as far into one as the other. A paint coating can be applied as quickly and easily to any surface as an oil coat; will dry as quickly and as hard, and is in every way a better resistant to atmospheric or mechanical injuries.

A foundation coat of oil is a direct cause of the blistering and peeling of the coatings spread over it. It is seldom dried enough before the other paints are spread over it to insure a close adherence to the metal it covers. When the subsequent coats of paint are spread, the solvents and oils in them soften to some extent the underlying coat of oil, and moderate heat from the sun cause the whole coating to blister or peel. Too much oil in a paint coating, particularly if the surplus oil is in or near the foundation coat, whether on a wooden or metallic surface, will generally cause peeling, regardless of the pigment used in the coatings.

In 1904 I examined with Mr. Byrnes, the engineer in charge, the Newtown Creek Bridge, New York city, a new structure then being erected, and on which had been applied a shop coat of boiled linseed oil, and we found the steel underneath very badly corroded, and he stated then that it would be the last time that he would ever allow the use of boiled linseed oil if he had anything to say about it.

A few months ago I had an occasion to examine one of the new piers being erected in New York city with the engineer and found the same trouble there—corrosion under a coating of boiled linseed oil and he was convinced that to specify linseed oil for a priming coat leads to poor results.

I might go on and cite many other cases, but I think that I have taken up enough time and produced enough evidence to show that linseed oil by itself is a bad thing. The question now arises—what pigment would you recommend using in connection with linseed oil for a priming coat? and to this I answer that the paint doctor must be advised upon several points before he can prescribe the proper pigment. Will the metal be painted under cover, and how much time will be allowed for drying? If it is a rush job, we want to use a pigment that will not retard the drying of the oil, as, for instance, carbon black is a very durable pigment, but it does not want to be used on a rush job. Is the material to be shipped a long distance? and what kind of exposure will it have before its second coat? Will the metal be properly cleaned before the shop coat is applied? All of these questions must be answered before we can state intelligently what is the best pigment to use. Where no information can be obtained, as a general rule it is safe to use a selected high-grade natural ore iron oxide paint, while for many locations a blue lead paint would be best and in others a combination of red lead and graphite, or a carbon black paint.

ITEMS OF INTEREST FROM VARIOUS LOCALITIES.

CONSTRUCTION work on the plant of the Yuma (Ariz.) Gas Company is under way. The site adjoins that on which the electric lighting plant is located on the east foot of Main street.

MESSRS. R. C. SMITH and H. C. Zacharias, of Camp Hill, Pa., and Mr. T. K. Van Dyke, of Harrisburgh, Pa., have applied for a charter under which to construct and operate a gas plant in the first named place.

AT the annual meeting of the shareholders in the Lansing (Mich.) Fuel and Gas Company the officers elected were: President, C. B. Kelsey; Vice-President, C. H. Geist; Secretary, C. W. Fox; Treasurer, B. F. Davis; Directors, R. W. Griswold, C. H. Geist, C. B. Kelsey, E. G. Filer, B. F. Davis, E. F. Cooley and R. E. Olds.

A CORRESPONDENT in Kokomo, Ind., writing under date of the 12th inst., incloses the following: "Doubtless the first gas pipe laid in Kendalville, Ind., was that laid into the home of Councilman A. H. Minor, even though the gas works are not built." Our correspondent adds, "And this is not the first pipe that the Councilman put through."

THE semi-annual payments made by the named Companies into the City Treasury of Cleveland, O., for the 6 months ended July 31st, were: Cleveland Gas Light and Coke Company, $28,511.25; Peoples Gas Light Company, $7,174.84.

MESSRS. R. D. WOOD & CO., of Philadelphia, have formally advised the Committee on Light, of the Richmond (Va.) City Councils, that they desire to surrender the contract under which they were to make the main pipe reconstruction in connection with the rehabilitation of the Richmond municipal gas works.

THE Public Service Commission, Second District, New York, has granted the application of the village of Sherburne, N. Y., for the right to operate on public and private account an electric lighting plant. The Commission has also authorized the Sherburne Gas Company to engage in business.

A CORRESPONDENT incloses the following: President F. G. Drum, of the Pacific Gas and Electric Company, of San Francisco, has issued a circular letter to the stockholders explaining the necessity of levying an assessment of $10 a share on the Company's 300,000 shares of stock, as recently decided upon by the Board of Directors. In this letter President Drum makes the interesting statement that the Company's net earnings for the first 6 months of this year were almost as large as for the entire year of 1906. The proposed assessment, therefore, is not to meet deficiencies, but to raise money to pay for improvements called for by the rapid growth of the many cities and towns served by the Company. In 1906 the Company earned net above all liabilities and obligations $690,898.07. For the first 6 months of this year it earned net $674,374.55, as nearly as much as was earned during the whole of last year. The conclusion is then drawn by President Drum that the surplus for the whole of this year should be something like $1,810,000. The letter also makes the announcement that in addition to the $10 assessment another financial plan will soon be decided upon to help pay the cost of large and necessary improvements. Continuing, the letter sets forth that in spite of favorable earnings they have been unable to take care of the following construction work: First, to rehabilitate the San Francisco system, following the fire of April 18-19-20, 1906; second, to take care of the abnormal growth of the Oakland division caused by the rapid peopling of that territory; third, in the care of contracts for light and power throughout our entire system, which contracts were made subsequent to April 1, 1906, these principally being in the nature of new cement work, interurban railways and gold dredgers on both the Feather and Yuba rivers. These improvements and extensions in the several plants, made necessary to preserve the integrity of the same, cost approximately $5,750,000. It may be confidently stated that, with the completion of the work in hand, the amount of which is represented in part by the increased debt mentioned, for 3 or 4 years to come no extraordinary extension of betterments need be made, and the usual growth of plants can readily be taken care of by the surplus. To pay the present indebtedness, as shown, a plan of financing is now in progress toward a very satisfactory conclusion. Of this all

stockholders will be, in due time, advised. It is considered that with the assessment and the financing that nearly, if not all, of the entire floating debt can be met, leaving a balance such as a Company of this character and importance may at all times be permitted to owe." What financial plan the Company will decide upon as supplemental to the stock assessment in order to meet the cost of improvements is not known, the Directors not being agreed on that subject as yet.

THROUGH Mr. Henry I. Lea, of Chicago, Mr. E. G. Cowdery has placed the contract for the new 24-foot diameter, circular steel purifiers for the plant of the Beloit (Wis.) Gas Company, with the Cruse-Kemper Company, of Philadelphia. The valves and yard connections are to be put in by the Isbell-Porter Company, of Newark, N. J.

THIS looks like going ahead some. The Lewiston (Idaho) Gas Company has been in active business for only a few months, but its success has been such that it is planned to double the generating capacity.

THE City Council of Abilene, Kas., has granted to Mr. R. Iams, of Clay Center, Kas., the right to construct and operate a gas works.

An odd plan of suicide was that successfully adopted by William Barnhizer, of Oskaloosa, Ia. On the night of the 3d inst., having finished his work on the linotype machine that he had been operating, he threw a mail sack over his head and turned on the "gas blower" that furnished fuel to the linotype apparatus. He was dead when the discovery of his act was made.

THE return made by the Providence (R. I.) Gas Company to the City Treasurer, under the royalty provision of its contract for the quarter ended June 30, was $6,750.75. For the corresponding quarter of 1906, the royalty amounted to $6,257.02.

MR. F. W. COLDWELL, formerly Treasurer and Auditor of the Oklahoma City Gas and Electric Light Company, has been appointed General Manager of the Shawnee Gas and Electric Company.

AT the annual meeting of the New Bedford (Mass.) Gas and Edison Light Company the officers elected were; Directors, H. G, Howland, T. H. Knowles, C. R. Price, G. R. Stetson, F. Taber, O. Prescott, Jr., J. S. Perry, H. M. Knowles, L. B. Bates, P. M. Lund and F. H. Gifford; Treasurer and Clerk, Chas. R. Price.

A VERY effective postal card, from an advertising point of view, is that entitled: "Even 'in darkest Africa.'" The card illustrates in excellent manner a Jeffrey locomotive hauling a train of cars carrying coal to the shaft of an African coal mine.

MR. ELMON SCOTT, of Walla Walla, Wash., has purchased 1,000 acres of desert land on Snake River, Wash., which he proposes to make tillable by the aid of irrigation, using gas pumps as the motor power.

THE Burlington (Ia.) Light and Power Company is constructing a double lift holder up to retaining 500,000 cubic feet.

MR. JAMES MCCAFFREY, Chairman of the Entertainment Committee Employees' Mutual Aid Association of the New York and Richmond (Staten Island) Gas Company, informs us that the Association's sixth annual outing will be held the 28th inst., at Happy Land, South Beach, S. I.

MR. GEORGE EBELS and Mr. Arthur English, respectively cashier and draughtsman with the Grand Rapids (Mich.) Gas Light Company, have resigned to assume positions on the engineering division of the force of a large copper mining concern with headquarters in Salt Lake City. Mr. F. R. Carew has been appointed to succeed Mr. English.

THE 95-cent net gas rate for Buffalo, N. Y., goes into effect the 1st prox. On hold-over accounts the penalty of 10 cents per 1,000 will remain operative.

MR. HOWARD L. OLDS informs us that the Commercial Securities Company, of Detroit, Mich., to which he is attached in an important and responsible way since his resignation from the Lloyd Construction Company, is building an entirely new gas plant at Three Rivers, Mich. The Company is also reconstructing an electric lighting and heating property at New Castle, Ind.

CERTAIN residents of Bellefontaine, O., are loud in their belief that municipal ownership, with the operation thereof as well, is the best thing for the people. Prominent in the list of those who so think are the 522 who are in arrears in their accounts. The indebtedness of the 522, up to the 1st inst., amounted to $3,781.70.

THE Board of Commissioners, District of Columbia, some weeks ago asked the Washington Gas Light Company to submit a statement of its receipts and expenditures for the twelvemonth ended December 31, 1906. The demand was complied with and the figures returned were: Receipts, $1,814,795.83; expenditures, $1,643,915.

THE new distributing main of the Lynn (Mass.) Gas and Electric Company is quite a bit of work. It is to carry gas to Saugus, and its route is up Commercial, via Neptune, West Neptune and Light streets to Houghton Square and out Summer street to Saugus. Col. McGregor, of Pawtucket, thinks that Mr. Prichard, the Lynn Company's astute Chief, will not be able to visit with him at Squantum this fall, owing to the aforesaid pipe laying operation. However, it is a certainty they will come together next fall, at the Washington meeting of the American Gas Institute, most likely.

A CORRESPONDENT in San Francisco, Cal., forwards the following: "The Pacific Gas and Electric Company, of San Francisco, which is a consolidation of the San Francisco Gas and Electric Company and the California Gas and Electric Corporation, the latter controlling the Bay Counties and other power Companies, has been strengthened financially through the efforts of the Eastern financiers who purchased a large interest in the system several years ago and have since increased their holdings. An election of officers has recently taken place, changing the personnel of the Company in several instances. Mr. Frank G. Drum has been elected President of the Pacific Gas and Electric Company. Mr. John A. Britton, who formerly occupied that office, is now the Vice-President of the Pacific Gas and Electric and the President of the San Francisco Gas and Electric Company, the California Gas and Electric Corporation and of all the other subsidiary corporations. He is also to be General Manager of all the companies. Mr. C. W. Conlisk has resigned the position of Secretary of the Pacific Gas and Electric Company. Messrs. John Martin and Eugene de Sabla, Jr., who have figured so prominently in these Companies since their organization, have retired from active control and have opened up offices, respectively, in the Merchants' Exchange Building and the French Bank Building, San Francisco. The Pacific Gas and Electric Company is planning several important improvements, which will materially benefit the service. Preparations have bee made to install at Station A of the San Francisco Gas and Electric Company, in the Potrero, an additional 5,000-kw., 11,000-volt, steam turbine generating set. A 1,500-kw. generating set is to be removed from the same station to the Pacific Company's steam relay plant at Petaluma. One of the 1,200-kw. direct current generating sets from the old Jessie street station, which has been damaged by 3 fires in the last 18 months, is being installed in the Mutual Electric Light Company's plant at Speer and Folsom streets, which is now under the control of the San Francisco Gas and Electric Company. A small storage battery is to be installed in Station C in place of the large one that was destroyed by fire. The gas system of the corporation is now in good working order in a number of outside cities as well as in San Francisco under the supervision of Mr. E. C. Jones. The largest plant is at Martin Station, 6 miles south of the city, where there are two 2,000,000 cubic foot gas generating units and a 2,000,000 foot gasholder. These supply the three large Snow gas engines, each direct connected to a Crocker-Wheeler 300-kw., 3-phase alternator. These gas engine units are kept in operation almost constantly, although they are intended to serve as a reserve plant. The Company's gas business at Sacramento has been growing, and an additional gasholder with a capacity of 500,000 cubic feet is being constructed there. An additional 100,000 cubic foot gas generator is also to be installed. Improvements and extensions are being made at the plants in Fresno, Santa Rosa and San Rafael. A 100,000 cubic foot gasholder is being erected in the last-named city. The gas business of Oakland and vicinity has doubled since the San Francisco disaster. An additional gasholder, having a capacity of 1,000,000 cubic feet, is being constructed, entirely above ground, on property near the Company's main plant in Oakland. A 20,000-barrel steel oil tank has been installed at Station B, near the corner of First and Market streets. This tank was moved from the old Pacific Gas Improvement Company's works at North Beach, San Francisco, on 2 scows to Oakland."

THE AMERICAN GAS LIGHT JOURNAL

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NOTIFICATION RESPECTING ADVERTISING.

Orders for new advertising, or for changes in standing advertisements, to insure attention in the issue following their reception, must be in hand any time of Wednesday.

AGENTS:

New York—American News Co., 39 and 41 Chambers St.
Germany—Lemcke & Buechner, of New York.
England—Aug. Siegle, 30 Lime Street, London.

MONDAY, AUGUST 19, 1907.

The Market for Gas Securities.

As far as the market for local gas securities goes, there is none. That sums up the situation. Just think of Consolidated gas at par! It sold at that figure yesterday morning. The one who bought that lot was a lucky one; the one who sold it was—well, let it go at that. The opening price to-day (Friday) was 103½ to 104. Brooklyn Union even "held up" better than Consolidated.

Strange to say, Peoples, of Chicago, was about as "steady" as anything on the list. That 6 per cent. payer went off but 10 points. Perhaps returning reason is on the way. Let us hope so, at any rate.

Gas Stocks.

Quotations by George W. Close, Broker and Dealer in Gas Stocks.

16 WALL STREET, NEW YORK CITY.

AUGUST 19.

☞ All communications will receive particular attention.

☞ The following quotations are based on the par value of $100 per share.

N. Y City Companies	*Capital.*	*Par.*	*Bid.*	*Asked.*
Consolidated	$73,177,000	100	103¾	104
Central Union Gas Co.—				
1st 5's due 1972, J & J	3,000,000	1,000	101	104
Equitable Gas Light Co.—				
Con. 5's, due 1932, M. & S.	1,000,000	1,000	..	105
Mutual	3,500,000	100	190	225
New Amsterdam Gas Co.—				
1st Con. 5's, due 1948, J. & J.	11,000,000	1,000	98	100
New York & Richmond Gas Co. (Staten Island)	1,500,000	100	37	43
1st Mtg. Gold Bds. 5 p.ct.	1,000,000	..	98	104
Northern Union—				
1st 5's, due 1927, J. & J.	1,250,000	1,000	101	103
New York and East River—				
1st 5's, due 1944, J. & J.	3,500,000	1,000	109	111
Con. 5's, due 1945, J. & J.	1,500,000	..	104	110
Standard	5,000,000	100	140	160
Preferred	5,000,000	100	155	175
1st Mtg. 5's, due 1930, M. & N	1,500,000	1,000	104	108
The Brooklyn Union	15,000,000	1,000	105	112
1st Con. 5's, due 1948, M. & N	15,000,000		109¾	112
Yonkers	299,650	500	130	..
Out-of-Town Companies.				
Bay State	50,000,000	50	¼	⅜
" Income Bonds	2,000,000	1,000	..	75
Binghamton Gas Works	450,000	100	..	65
" 1st Mtg. 5's	500,000	1,000	95	100
Boston United Gas Co.—				
1st Series S. F. Trust	7,000,000	1,000	82	85
2d " " "	3,000,000	1,000	47½	50
Buffalo City Gas Co.	5,500,000	100	9	10
" " Bonds, 5's	5,250,000	1,000	75	80
Capital, Sacramento	500,000	50	..	35
Bonds (6's)	150,000	1,000	..	..
Chicago Gas Co. Guaranteed Gold Bonds	7,650,000	1,000	104	106¾
Cincinnati Gas and Electric Co.	29,500,000	100	96¼	97
Columbus (O.) Gas Co., 1st Mortgage Bonds	1,500,000	1,000	90	..
Columbus (O.) Gas Lt. & Heating Co	1,682,750	100	87	88
Preferred	3,026,500	100	107½	108
Consumers, Toronto	2,000,000	50	200	204
Consolidated, Baltimore	11,000,000	100	..	90
Mortgage, 6's	3,500,000	..	..	118
Chesapeake, 1st 6's	1,000,000	..	..	..
Equitable, 1st 6's	910,000	..	..	..
Consolidated, 1st 5's	1,490 000	..	..	112
Consolidated Gas Co. of N. J.	1,000,000	100	15	17
Con. Mtg. 5's	880,000	1,000	92	95
Bonds	75,000	..	..	100
Detroit City Gas Co.	5,000,000	50	..	50
" Prior Lien 5's	4,618,000	1,000	..	98
Detroit Gas Co., 5's	331,000	1,000	75	80
" Inc. 5's	16,000	100	98½	100
Equitable Gas & Fuel Co., Chicago, Bonds	2,000,000	1,000	..	101
Essex and Hudson Gas Co.	6,500,000	..	39	40
Fort Wayne	2,000,000	..	..	..
" Bonds	2,000,000	..	55	..
Grand Rapids Gas Lt. Co. 1st Mtg. 5's	1,225,000	1,000	104½	105
Hartford	750,000	25	190	200
Hudson County Gas Co., of New Jersey	10,500,000	..	110	112
Bonds, 5's	10,500,000	..	107½	108½
Indianapolis	2,000,000	..	60	70
" Bonds, 5's	2,650,000	..	104½	105
Jackson Gas Co.	250,000	50	82	..
" 1st Mtg. 5's	290,000	1,000	97	100
Kansas City Gas Light Co., of Missouri	5,000,000	100	..	36
Bonds, 1st 5's	3,823,000	1,000	102	104
Laclede, St. Louis	10,000,000	100	..	95
Preferred	2,500,000	100	95	110
Bonds	10,000,000	1,000	104	104½
Lafayette Gas Co., Ind.	1,000,000	100	..	60
Bonds	1,000,000	1,000	60	65
Louisville	2,570,000	50	143	145
Madison Gas & Elec. Co.				
" 1st Mtg. 6's	350,000	1,000	106	108¾
" 6 per cent. scrip, due 1910	100,000	25	50	53
Massachusetts Gas Companies of Boston	25,000,000	100	50¾	51
Preferred	25,000,000	100	82	82½
Montreal, Canada	2,000,000	100	218	218¾
Nashville Gas Lt. Co.	1,000,000	100	110	..
Newark, N. J., Con. Gas Co.	6,000,000	..	56	58
Bonds, 6's	6,000,000	..	137	138
New Haven	2,000,000	25	200	..
Peoples G. L. & Coke Co., of Chicago	25,000,000	100	85	86½
Peoples Gas Lt. & Coke Co., Chicago, 1st Mortgage	30,100,000	1,000	..	..
" 2d "	2,500,000	1,000	104	..
Rochester Gas & Elec. Co.	2,150,000	50	88	..
Preferred	2,150,000	50	116	..
Consolidated 5's	2,000,000	..	104½	105¼
San Francisco, Cal.	15,800,000	00	..	..
St. Joseph Gas Co. 1st Mtg. 5's	751,000	1,000	92	..
St. Paul Gas Light Co	1,500,000	100	45	47
1st Mortgage 6's	650,000	1,000	113	116
Extension, 6's	600,000	1,000	112½	115
General Mortgage, 5's	2,485,000	1,000	96¾	..
Syracuse, N. Y.	1,975,000	100	50	55
Bonds	2,047 000	1,000	102	..
Washington, D. C	2,500,000	20	375	390
First mortgage 6's	600,000	..	..	..
Western, Milwaukee	4,000,000	..	..	..
Wilmington, Del.	600,000	50	220	..

Advertisers' Index.

GAS ENGINEERS. Page

A. E. Boardman, New York City ... 333
Baxter & Young, Detroit, Mich ... 343
B. E. Chollar, St. Louis, Mo ... 336
Cruse-Kemper Co., Philadelphia, Pa ... 332
Davis & Farnum Mfg. Co., Waltham, Mass ... 344
Economical Gas Apparatus Construc'n Co., Toronto, Ont 343
Frank D. Moses, Trenton, N. J ... 346
Frederic Egner, Norfolk, Va ... 348
H. M. Byllesby & Co., Chicago, Ills ... 344
Humphreys & Glasgow, New York City ... 344
Isbell-Porter Co., Newark, N. J ... 332
Kerr Murray Mfg. Co., Fort Wayne, Ind ... 345
Practical Gas Construction Co., North Chicago, Ills ... 344
The Gas Machinery Co., Cleveland, O ... 328
The Jeffrey Manufacturing Co., Columbus, O ... 342
United Gas Improvement Co., Philadelphia, Pa ... 339
Western Gas Construction Co., Fort Wayne, Ind ... 352

GAS WORKS APPARATUS AND CONSTRUCTION.

A. E. Boardman, New York City ... 333
Bartlett, Hayward & Co., Baltimore, Md ... 345
Baxter & Young, Detroit, Mich ... 343
Connelly Iron Sponge & Governor Co., New York City ... 341
Continental Iron Works, Brooklyn, N. Y ... 346
Cruse-Kemper Co., Philadelphia, Pa ... 332
Davis & Farnum Mfg. Co., Waltham, Mass ... 344
Delly & Fowler, Philadelphia, Pa ... 348
Economical Gas Apparatus Construc'n Co., Toronto, Ont. 343
Frank D. Moses, Trenton, N. J ... 346
Humphreys & Glasgow, New York City ... 344
Isbell-Porter Company, New York City ... 332
Kerr Murray Mfg. Co., Fort Wayne, Ind ... 345
Lloyd Construction Co., Detroit, Mich ... 334
Logan Iron Works, Brooklyn, N. Y ... 348
Quintard Iron Works, New York City ... 344
R. D. Wood & Co., Philadelphia, Pa ... 346
Riter-Conley Mfg. Co., Pittsburgh, Pa ... 347
Stacey Mfg. Co., Cincinnati, O ... 347
The Gas Machinery Co., Cleveland, O ... 328
The Jeffrey Manufacturing Co., Columbus, O ... 342
United Gas Improvement Co., Philadelphia, Pa ... 339
Western Gas Construction Co., Fort Wayne, Ind ... 352

PROCESSES.

Bartlett, Hayward & Co., Baltimore, Md ... 345
B. E. Chollar, St. Louis, Mo ... 336
Economical Gas Apparatus Construc'n Co, Toronto, Ont 343
Humphreys & Glasgow, New York City ... 344
Semet-Solvay Co., Syracuse, N. Y ... 342
The Gas Machinery Co., Cleveland, O ... 328
United Gas Improvement Co., Philadelphia, Pa ... 339
Western Gas Construction Co., Fort Wayne, Ind ... 352

SCRUBBERS AND CONDENSERS.

Continental Iron Works, Brooklyn, N. Y ... 346
Cruse-Kemper Co., Philadelphia, Pa ... 332
Davis & Farnum Mfg. Co., Waltham, Mass ... 344
Economical Gas Apparatus Construc. Co., Toronto, Ont 343
Isbell-Porter Co., Newark, N. J ... 332
Kerr Murray Mfg. Co., Fort Wayne, Ind ... 345
Logan Iron Works, Brooklyn, N. Y ... 348
R. D. Wood & Co., Philadelphia, Pa ... 346
Riter-Conley Mfg. Co., Pittsburgh, Pa ... 347
Stacey Mfg. Co., Cincinnati, O ... 347
The Gas Machinery Co., Cleveland, O ... 328
Western Gas Construction Co., Fort Wayne, Ind ... 352

PRODUCER POWER PLANTS.

Economical Gas Apparatus Construc. Co., Toronto, Ont. 343
R. D. Wood & Co., Philadelphia, Pa ... 346

TAR AND CARBONIC ACID EXTRACTOR.

Economical Gas Apparatus Construc'n Co., Toronto, Ont 343
Isbell-Porter Co., Newark, N. J ... 332
Kerr Murray Mfg. Co., Fort Wayne, Ind ... 345
Stacey Mfg. Co., Cincinnati, O ... 347
The Gas Machinery Co., Cleveland, O ... 328
Western Gas Construction Co., Fort Wayne, Ind ... 352

AMMONIA CONCENTRATORS.

Michigan Ammonia Works, Detroit, Mich ... 338
The Gas Machinery Co., Cleveland, O ... 328
Western Gas Construction Co., Fort Wayne, Ind ... 352

GAS METERS.

American Meter Co., New York and Philadelphia ... 351
Detroit Meter Company, Detroit, Mich ... 351
D. McDonald & Co., Albany, N. Y ... 349
Helme & McIlhenny, Philadelphia, Pa ... 351
John J. Griffin & Co., Philadelphia, Pa ... 308
Keystone Meter Co., Boyersford, Pa ... 350
Maryland Meter and Mfg. Co., Baltimore, Md ... 350
Metric Metal Co., Erie, Pa ... 351
Nathaniel Tufts Meter Co., Boston, Mass ... 350
New York Improved Meter Co., New York City ... 350
Pittsburg Meter Co., East Pittsburg, Pa ... 349
Rotary Meter Co., New York City ... 327
United States Meter Co., Brooklyn, N. Y ... 331

PREPAYMENT METERS.

American Meter Co., New York and Philadelphia..... 351
D. McDonald & Co., Albany, N. Y..... 349
Helme & McIlhenny, Philadelphia, Pa..... 351
John J. Griffin & Co., Philadelphia, Pa..... 308
Keystone Meter Co., Royersford, Pa..... 350
Nathaniel Tufts Meter Co., Boston, Mass..... 350
New York Improved Meter Co., New York City..... 350
Pittsburg Meter Co., East Pittsburg, Pa..... 349

PREPAYMENT METER ATTACHMENTS.

New York Improved Meter Co., New York City..... 350

WATER METERS.

Pittsburg Meter Co., East Pittsburg, Pa..... 349

GAS AND WATER PIPES.

Davis & Farnum Mfg. Co., Waltham, Mass..... 344
Donaldson Iron Co., Emaus, Pa..... 336
Economical Gas Apparatus Construc'n Co., Toronto, Ont. 343
R. D. Wood & Co., Philadelphia, Pa..... 341
Warren Foundry and Machine Co., New York City..... 336

GAS COALS.

Berwind-White Coal Mining Co., New York and Phila. 342
Perkins Co., New York City..... 342
Westmoreland Gas Coal Co., Philadelphia, Pa..... 343

SPECIALTIES FOR OIL AND PIPE LINES.

S. R. Dresser, Bradford, Pa..... 330

GAS MAIN STOPPERS.

Safety Gas Main Stopper Co., New York City..... 336

MAIN AND SERVICE LAYING.

Sullivan Bros., Flushing, N. Y..... 316

GAS TAPPING MACHINES.

George Light, Dayton, O..... 336
H. Mueller Manufacturing Co., Decatur, Ills..... 326

CANNEL COALS.

Perkins & Co., New York City..... 342

STOKING MACHINERY.

G. A. Bronder, New York City..... 341

CONVEYORS.

Cruse-Kemper Co., Philadelphia, Pa..... 332
C. W. Hunt Company, New York City..... 333
Economical Gas Apparatus Construc'n Co., Toronto, Ont 343
G. A. Bronder, New York City..... 341
Kerr Murray Mfg. Co., Fort Wayne, Ind 345
The Gas Machinery Co., Cleveland, O..... 328
The Jeffrey Manufacturing Co., Columbus, O..... 342
Western Gas Construction Co., Fort Wayne, Ind..... 352

CHARGING BARROWS & COAL WAGONS.

Davis & Farnum Mfg. Co., Waltham, Mass..... 344
Kerr Murray Mfg. Co., Fort Wayne, Ind..... 345
Stacey Mfg. Co., Cincinnati, O..... 347

GAS ENRICHERS.

Standard Oil Co., New York City..... 343

COKE CRUSHERS.

C. M. Keller, Columbus, Ind..... 343
The Jeffrey Manufacturing Co., Columbus, O..... 342

GAS METER CONNECTIONS.

H. Mueller Manufacturing Co., Decatur, Ills..... 326

GAS COCKS.

H. Mueller Manufacturing Co., Decatur, Ills..... 326

GAS GAUGES.

The Bristol Co., Waterbury, Conn..... 333

GAS GOVERNORS.

Chaplin-Fulton Mfg. Co., Pittsburgh, Pa..... 326
Connelly Iron Sponge & Governor Co., New York City. 331
Isbell-Porter Co., Newark, N. J..... 332
Pittsburg Meter Co., East Pittsburg, Pa..... 349
R. D. Wood & Co., Philadelphia, Pa..... 346
Reynolds Gas Regulator Co., Anderson, Ind..... 333

FUEL ECONOMIZERS.

Green Fuel Economizer Co., Matteawan, N. Y..... 333

CEMENTS.

C. L. Gerould, Pittsburgh, Pa..... 346

RETORTS AND FIREBRICKS.

Baltimore Retort and Firebrick Co., Baltimore, Md. ... 340
Gas Bench Construction Co., St. Louis, Mo. 340
Henry Maurer & Son, New York City..... 333
James Gardner, Jr., Co., Bolivar, Pa..... 342
J. H. Gautier & Co, Jersey City, N. J..... 340
Laclede-Christy Clay Products Co., St. Louis, Mo..... 329
Missouri Firebrick Co., St. Louis, Mo..... 340
Parker-Russell Mining and Mfg. Co., St. Louis, Mo.... 331

INCLINED RETORTS.

Baltimore Retort and Firebrick Co., Baltimore, Md..... 340
Gas Bench Construction Co., St. Louis, Mo..... 340
Laclede-Christy Clay Products Co., St. Louis, Mo..... 329
Parker-Russell Mining and Mfg. Co., St. Louis, Mo..... 331

VERTICAL S'S.

Connelly Iron Sponge & Gov. Co. (Drake's [Eng.] System) 341
Gas Bench Construction Co., St. Louis, Mo..... 340
Laclede-Christy Clay Products Co., St. Louis, Mo..... 329
Parker-Russell Mining and Mfg. Co., St. Louis, Mo..... 331

REGENERATIVE FURNACES.

Baltimore Retort and Firebrick Co., Baltimore, Md..... 340
Bartlett, Hayward & Co., Baltimore, Md 345
Gas Bench Construction Co., St. Louis, Mo..... 340
J. H. Gautier & Co., Jersey City, N. J..... 340
Laclede-Christy Clay Products Co., St. Louis, Mo..... 329
Missouri Firebrick Co., St. Louis, Mo..... 340
Parker-Russell Mining and Mfg. Co., St. Louis, Mo..... 331

SELF-SEALING MOUTHPIECE DOORS.

Continental Iron Works, Brooklyn, N. Y..... 346
Davis & Farnum Mfg. Co., Waltham, Mass..... 344
Isbell-Porter Co., Newark, N. J..... 332
Kerr Murray Mfg. Co., Fort Wayne, Ind..... 345
Logan Iron Works, Brooklyn, N. Y..... 348
R. D. Wood & Co., Philadelphia, Pa..... 346
Stacey Mfg. Co., Cincinnati, O..... 347
The Gas Machinery Co., Cleveland, O..... 328
Western Gas Construction Co., Fort Wayne, Ind..... 352

INCANDESCENT GAS LAMPS.

General Gas Light Co., Kalamazoo, Mich..... 335
Geo. G. Ramsdell, New York City..... 330
Welsbach Company, Gloucester, N. J..... 338

BURNERS.

Wm. M. Crane Co., New York City..... 330

STREET LAMPS.

Thos. T. W. Miner, New York City..... 336
Welsbach Street Lighting Co., New York and Phila... 338

PURIFIERS.

Connelly Iron Sponge & Governor Co., New York City.. 341
Cruse-Kemper Co., Philadelphia, Pa..... 332
Davis & Farnum Mfg. Co., Waltham, Mass..... 344
Isbell-Porter Co., Newark, N. J..... 332
Kerr Murray Mfg Co., Fort Wayne, Ind..... 345
R. D. Wood & Co., Philadelphia, Pa..... 346
Stacey Mfg. Co., Cincinnati, O..... 347
Western Gas Construction Co., Fort Wayne, Ind..... 352

PURIFYING MATERIALS.

Connelly Iron Sponge & Governor Co., New York City.. 341

VALVES.

Continental Iron Works, Brooklyn, N. Y..... 346
Davis & Farnum Mfg. Co., Waltham, Mass..... 344
Economical Gas Apparatus Construc'n Co, Toronto, Ont 343
Isbell-Porter Co., Newark, N. J..... 332
Kerr Murray Mfg. Co., Fort Wayne, Ind..... 345
Ludlow Valve Manufacturing Co., Troy, N. Y..... 333
R. D. Wood & Co., Philadelphia, Pa..... 346
Stacey Mfg. Co., Cincinnati, O..... 347
The P. H. & F. M. Roots Co., Connersville, Ind..... 335
Western Gas Construction Co., Fort Wayne, Ind..... 352

(Continued on page 336.)

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(Concluded from page 325.)

EXHAUSTERS.

Connelly Iron Sponge & Governor Co., New York City.. 341
Connersville Blower Co., Connersville, Ind..... 328
Davis & Farnum Mfg. Co., Waltham, Mass..... 344
Isbell-Porter Company, Newark, N. J..... 332
Kerr Murray Mfg. Co., Fort Wayne, Ind..... 345
The P. H. & F. M. Roots Co., Connersville, Ind..... 335

PURIFIER AND SCRUBBER TRAYS.

Cabot Mfg. Co., Hoboken, N. J..... 343
Western Gas Construction Co., Fort Wayne, Ind..... 352

GAS STOVES.

American Meter Co., New York and Philadelphia..... 351
Keystone Meter Co., Royersford, Pa..... 350
Maryland Meter & Manufacturing Co., Baltimore, Md.. 354
Nathaniel Tufts Meter Co., Boston, Mass..... 350
Stamford Gas Stove Co., Stamford, Conn..... 326

HOT WATER HEATERS.

Humphrey Co., Kalamazoo, Mich..... 331

GASHOLDER TANKS.

J. P. Whittier, Brooklyn, N. Y..... 346

GASHOLDERS.

Bartlett, Hayward & Co., Baltimore, Md..... 345
Continental Iron Works, Brooklyn, N. Y..... 346
Cruse-Kemper Co., Philadelphia, Pa..... 342
Davis & Farnum Mfg. Co., Waltham, Mass..... 344
Deily & Fowler, Philadelphia, Pa..... 348
Economical Gas Apparatus Construc'n Co., Toronto, Ont 349
Kerr Murray Mfg. Co., Fort Wayne, Ind..... 345
Logan Iron Works, Brooklyn, N. Y..... 348
R. D. Wood & Co., Philadelphia, Pa..... 346
Riter-Conley Mfg. Co., Pittsburgh, Pa..... 347
Stacey Mfg. Co., Cincinnati, O..... 347
Western Gas Construction Co., Fort Wayne, Ind..... 352

STORAGE TANKS.

Davis & Farnum Mfg. Co., Waltham, Mass..... 344
Stacey Mfg. Co., Cincinnati, O..... 347
Western Gas Construction Co., Fort Wayne, Ind..... 352

PATENTS, TRADE-MARKS, COPYRIGHTS.

Royal E. Burnham, Washington, D. C..... 343

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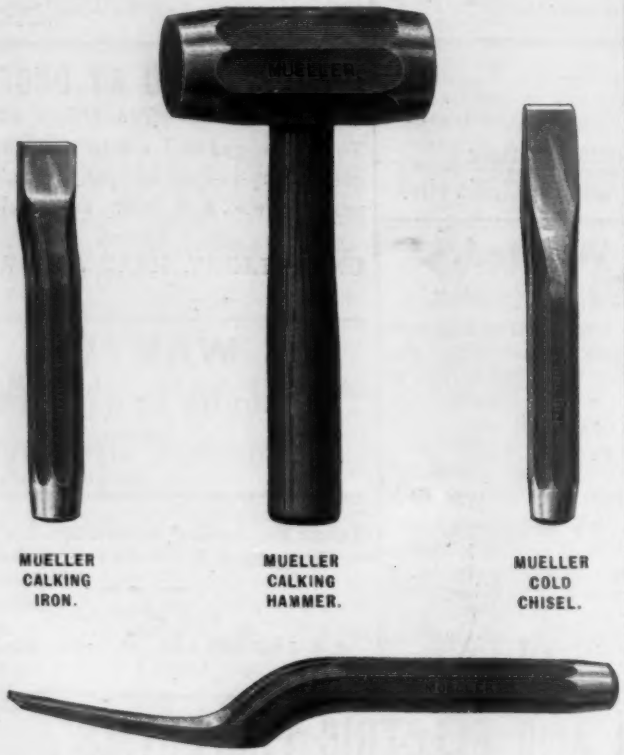

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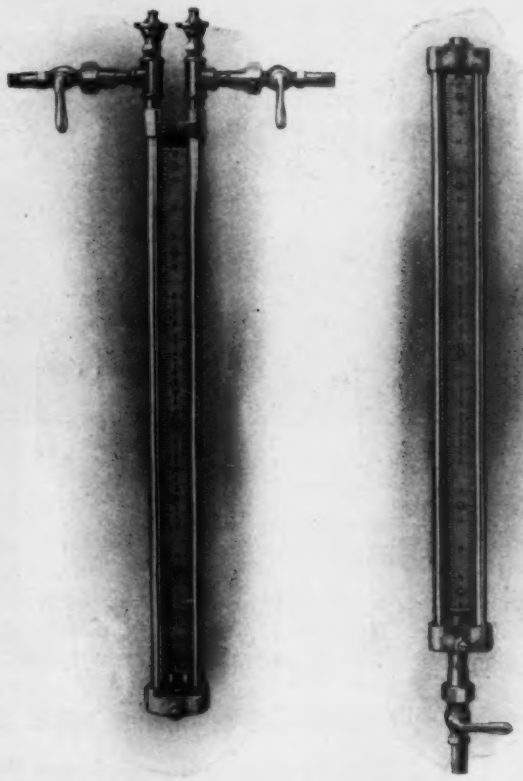

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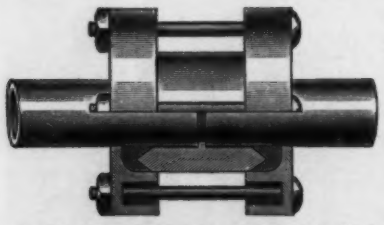
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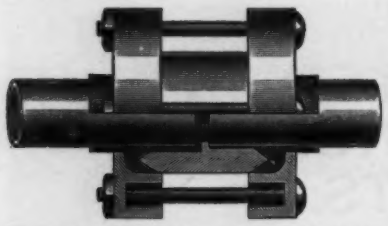
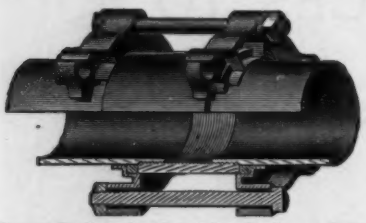
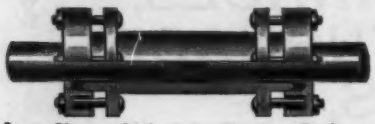

Insulating Coupling, Style 8, for Plain End Wrought Iron Pipe.


Clamp, Style 4, for Repairing Leaks on Screw Collar.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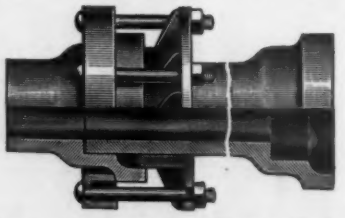
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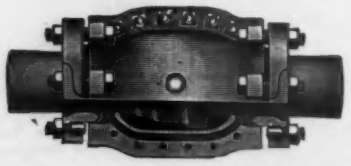
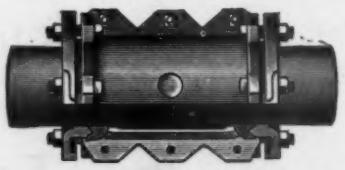
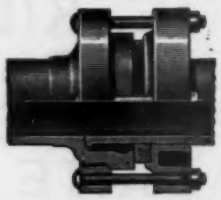
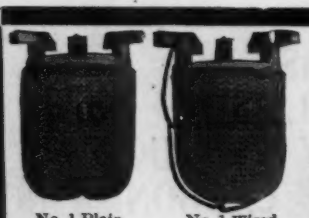
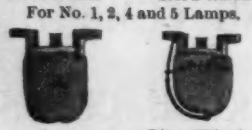

Split Sleeve for Repairing Broken Bell on Cast Iron Pipe.


Split Sleeve for Repairing Broken or Cracked Cast Iron Pipe.


Clamp, Style 4½, for Repairing Leaky Lead or Cement Joints in Cast Iron Pipe.


No. 1 Plain. No. 1 Wired
For No. 1, 2, 4 and 5 Lamps.


Bijou. Bijou Wired.
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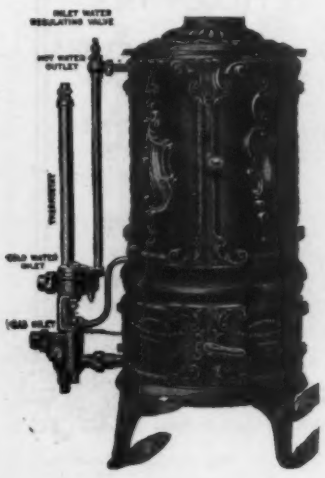

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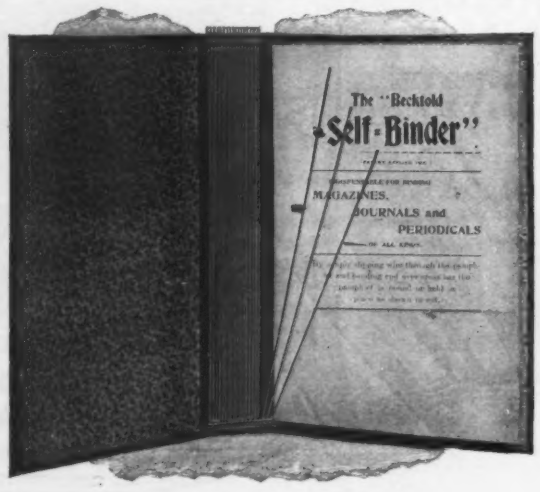

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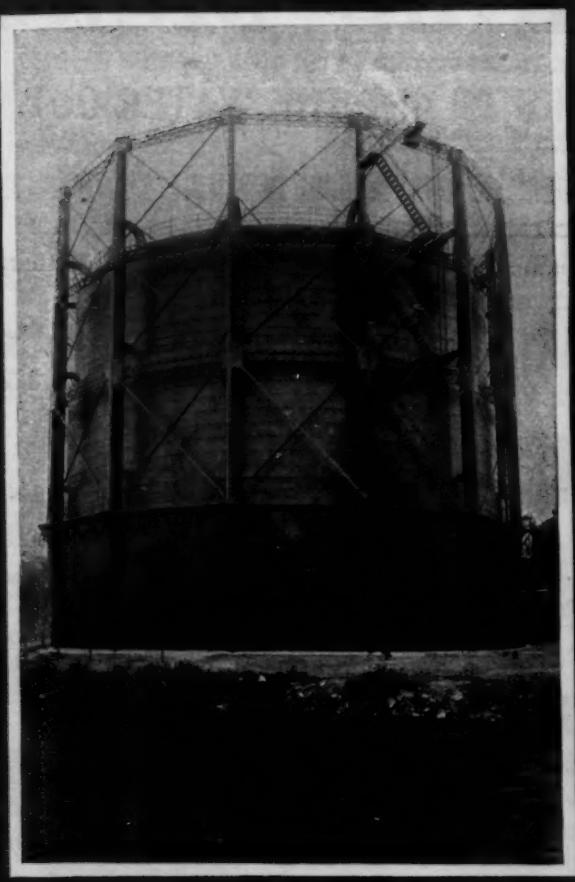

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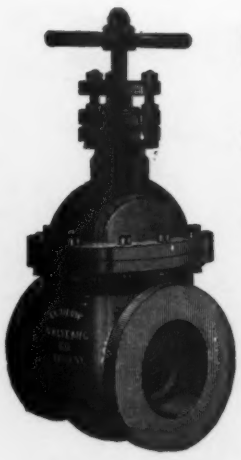

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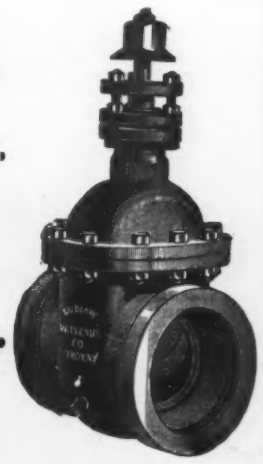

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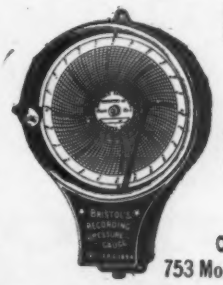
Used the World Over.
Necessary Equipment



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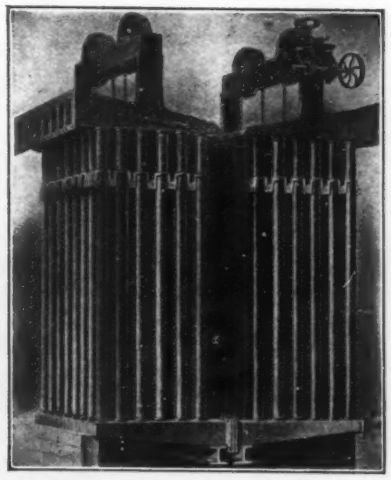

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After the gases have passed through the air heater they are still hot enough to use in a Green Fuel Economizer to heat the boiler-feed water up to the evaporative point. In In this way a quarter of the boiler coal can be saved. In connection with a 6-ft. generator an investment of $3,500 in an Air Heater and an Economizer will save from $2,300 to $2,500 per year. This ought to repay you for the trouble of writing us for further information. Ask for Circular "AG."

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12-inch High Pressure Governor.

REYNOLDS' GAS REGULATOR COMPANY,
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DOUBLE and SINGLE DISTRICT STATIONS,
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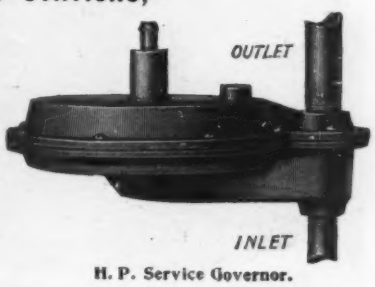

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THE
LLOYD
INTENSIVE
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WHY DO GAS EXHAUSTERS
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Stand so High in the estimation of those using them?
THE ANSWER IS IN THREE WORDS:

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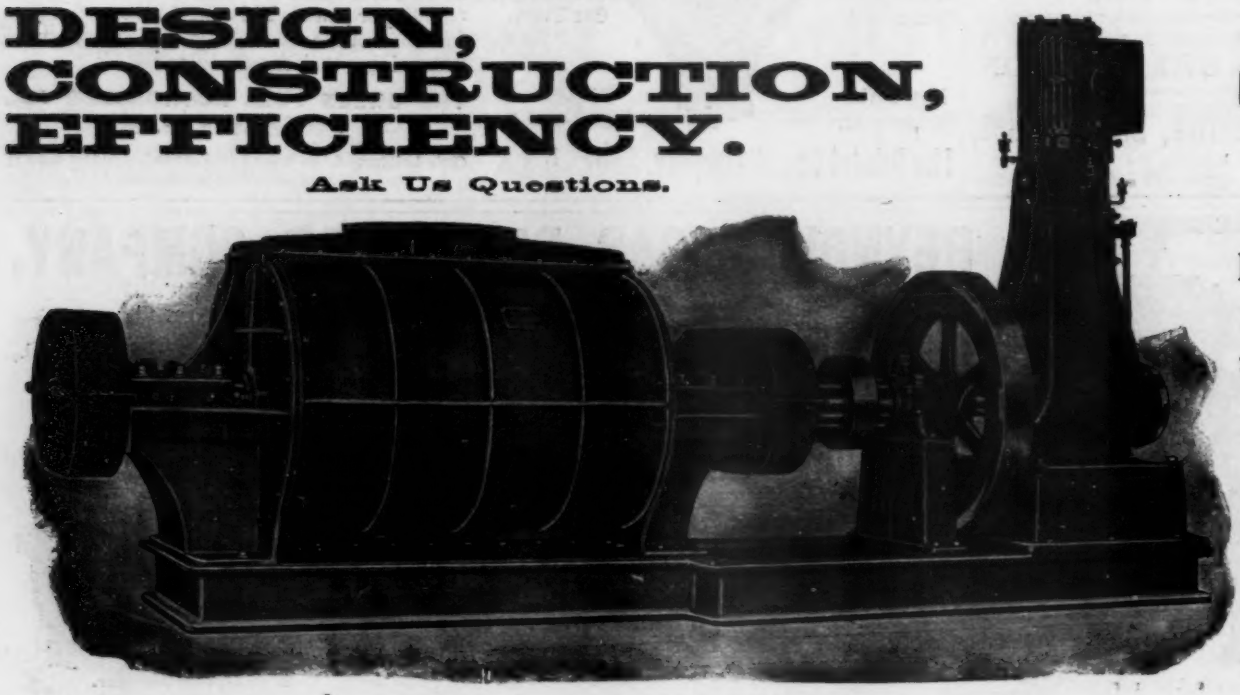

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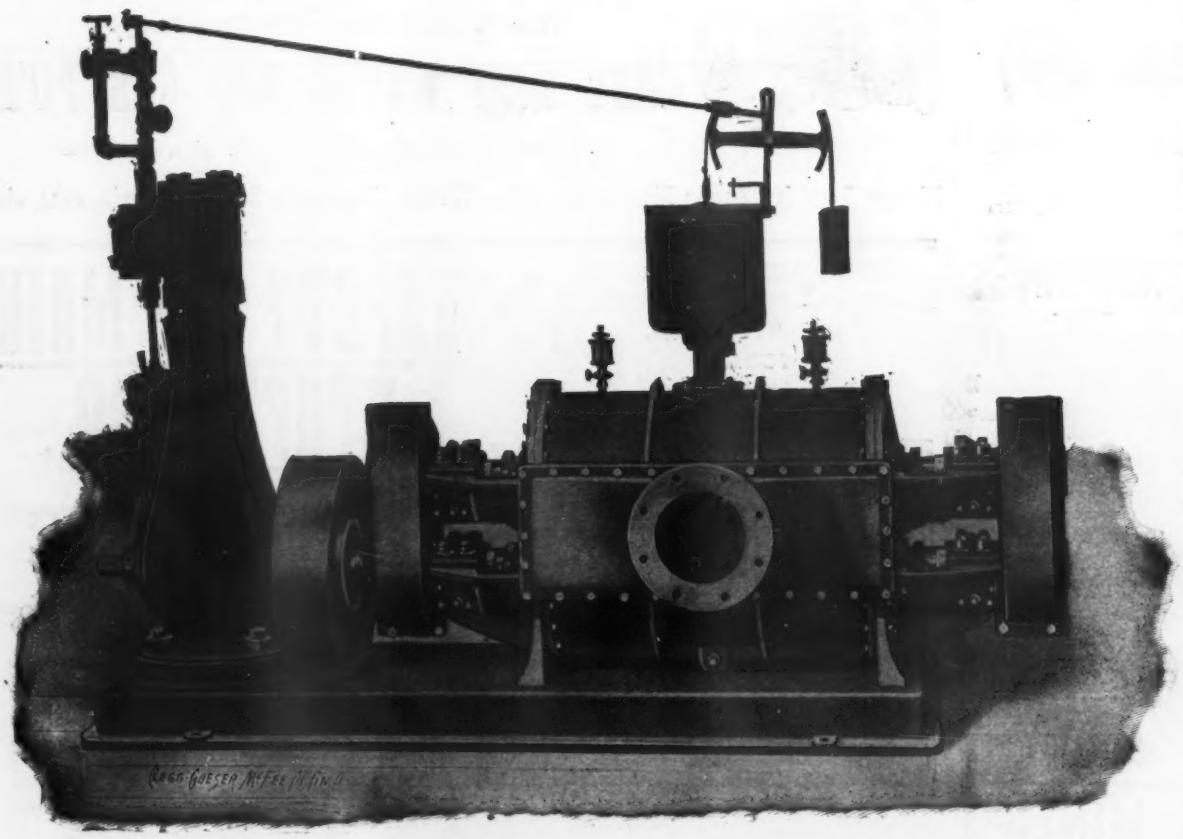

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Most perfect and sensitive Governor.

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Chollar's System of Gas Purification.

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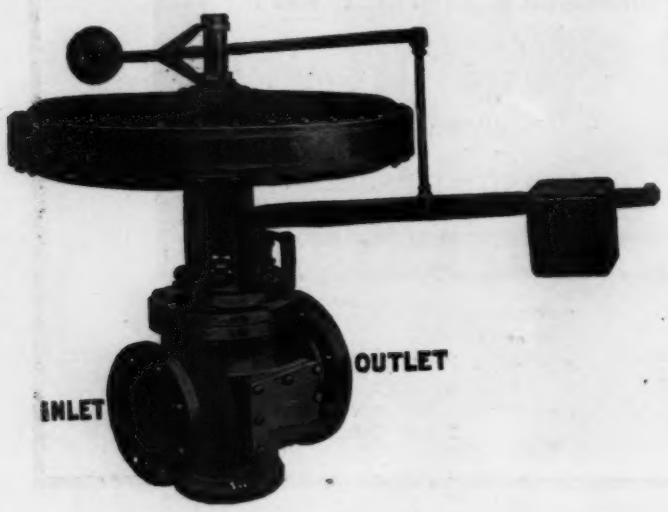

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For Artificial or Natural Gas.
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Our DUPLEX SENSITIVE GOVERNOR, with Automatic Cutoff for district service, will reduce high pressure gas to inches of water without variation.

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Photometrical and Experimental Apparatus.

PUBLIC LIGHTING TABLE.

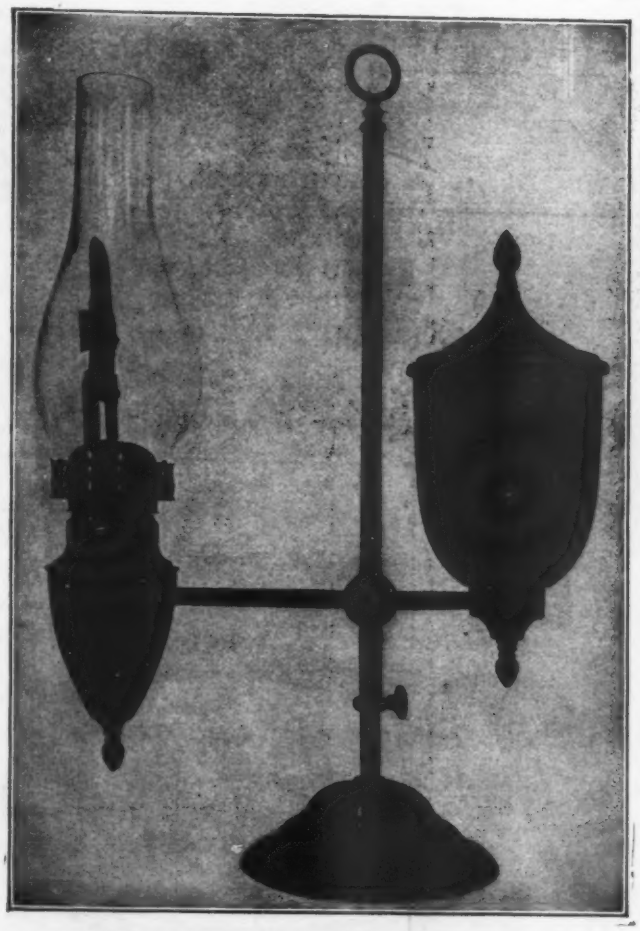
SEPTEMBER, 1907.

Day of Week.	Table No. 1. Following the Moon. Date.	Light.	Extinguish.
Sun.	1	7.00 PM	1.20 AM
Mon.	2	7.0	2.10
Tue.	3	7.00	3.10
Wed.	4	7.00	4.30
Thu.	5	7.00	4.30
Fri.	6	7.00	4.30
Sat.	7	7.00 NM	4.30
Sun	8	6.50	4.40
Mon.	9	6.50	4.40
Tue.	10	6.50	4.40
Wed.	11	6.50	4.40
Thu.	12	8.10	4.40
Fri.	13	8.50	4.40
Sat.	14	9.40 FQ	4.40
Sun.	15	10.30	4.40
Mon.	16	11.30	4.40
Tue.	17	12.30 AM	4.40
Wed.	18	1.50	4.40
Thu.	19	3.00	4.40
Fri.	20	No L.	No L.
Sat.	21	No L FM	No L.
Sun.	22	No L.	No L.
Mon.	23	6.20 PM	8.20 PM
Tue.	24	6.20	8.50
Wed.	25	6.20	9.20
Thu.	26	6.20	10.00
Fri.	27	6.20	10.40
Sat.	28	6.20 LQ	11.20
Sun.	29	6.10	12.00
Mon	30	6.10	1.00 AM

TOTAL HOURS DURING 1907.

By Table No. 1.

	Hrs.Min.
January	211.10
February	193.40
March	182.10
April	167.00
May	157.00
June	145.30
July	151.50
August	162.30
September	175.30
October	202.40
November	209.30
December	231.50
Total, yr.	2190.20



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✻✻✻

10-Candle Power.

✻✻✻

This lamp is a perfect substitute for the 10-candle Pentane Lamp hitherto used, and has the following advantages:

1st. It uses Standard Kerosene Oil (Pratt's Astral Oil or equivalent).

2d. It is remarkably steady. Will burn 24 hours continuously with less than 2 per cent. variation.

3d. It is much less dangerous than Pentane, which is a kind of gasolene.

4th. It is not easily affected by air currents in the photometer room.

5th. Since the lamp may burn continuously, the candle power of gas may be taken at any moment, if necessary. This insures steady illuminating power without waste of carburetting material.

6th. The first cost of the lamp brings it within the reach of even small gas works.

7th. Costs much less to maintain than a Pentane lamp or sperm candles doing the same service.

8th. Is not affected by the weather.

PUBLIC LIGHTING TABLE.

SEPTEMBER, 1907.

Day of Week.	Table No. 2. New York City. All Night Lighting. Date.	Light. P. M.	Extinguish. A. M.
Sun.	1	6.30	4.20
Mon.	2	6.30	4.20
Tue.	3	6.15	4.30
Wed.	4	6.15	4.30
Thu.	5	6.15	4.30
Fri.	6	6.15	4.30
Sat.	7	6.15	4.30
Sun.	8	6.15	4.30
Mon.	9	6.15	4.30
Tue.	10	6.05	4.40
Wed.	11	6.05	4.40
Thu.	12	6.05	4.40
Fri.	13	6.05	4.40
Sat.	14	6.05	4.40
Sun	15	6.05	4.40
Mon.	16	6.05	4.40
Tue.	17	5.55	4.50
Wed.	18	5.55	4.50
Thu.	19	5.55	4.50
Fri.	20	5.55	4.50
Sat.	21	5.55	4.50
Sun.	22	5.55	4.50
Mon.	23	5.55	4.50
Tue.	24	5.40	5.00
Wed.	25	5.40	5.00
Thu.	26	5.40	5.00
Fri.	27	5.40	5.00
Sat.	28	5.40	5.00
Sun.	29	5.40	5.00
Mon.	30	5.40	5.00

TOTAL HOURS DURING 1907.

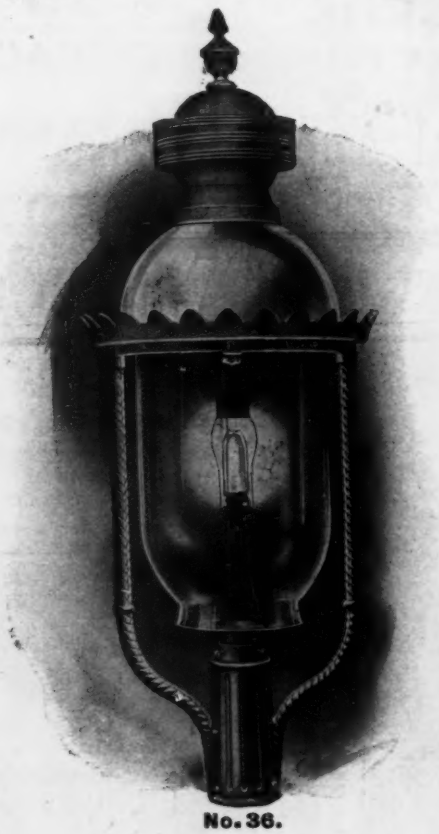
By Table No. 2.

	Hrs.Min.
January	423.20
February	355.25
March	355.35
April	298.50
May	264.50
June	234.25
July	243.45
August	280.25
September	321.15
October	374.30
November	401.40
December	433.45
Total, yr.	3987.45

NEW YORK, 318 West 42d Street. BOSTON, 820 Beacon Building. PHILADELPHIA, Broad and Arch Streets. ST. LOUIS, 712 Roe Building. CHICAGO, 218 La Salle Street. SAN FRANCISCO, 512 Oak Street.

WELSBACH STREET LIGHTING COMPANY

....OF AMERICA....



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Which includes its specially DESIGNED and PATENTED BURNER for PARK LIGHTING exclusively.

Uniformly SUCCESSFUL in 150 Cities and Towns.

By means of the Welsbach System of street lighting the superiority of GAS over electricity for street lighting has been fully demonstrated.

POINTS OF MERIT:

It is { Economical, Attractive, Successful, Up-to-date.

IT LIGHTS THE STREET.

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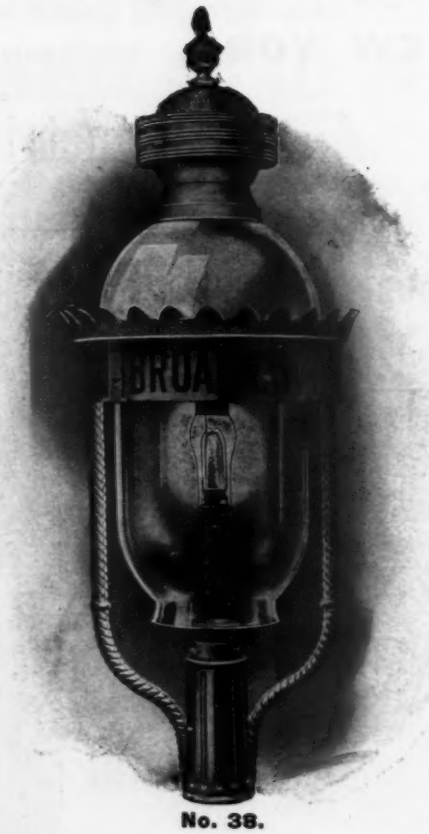

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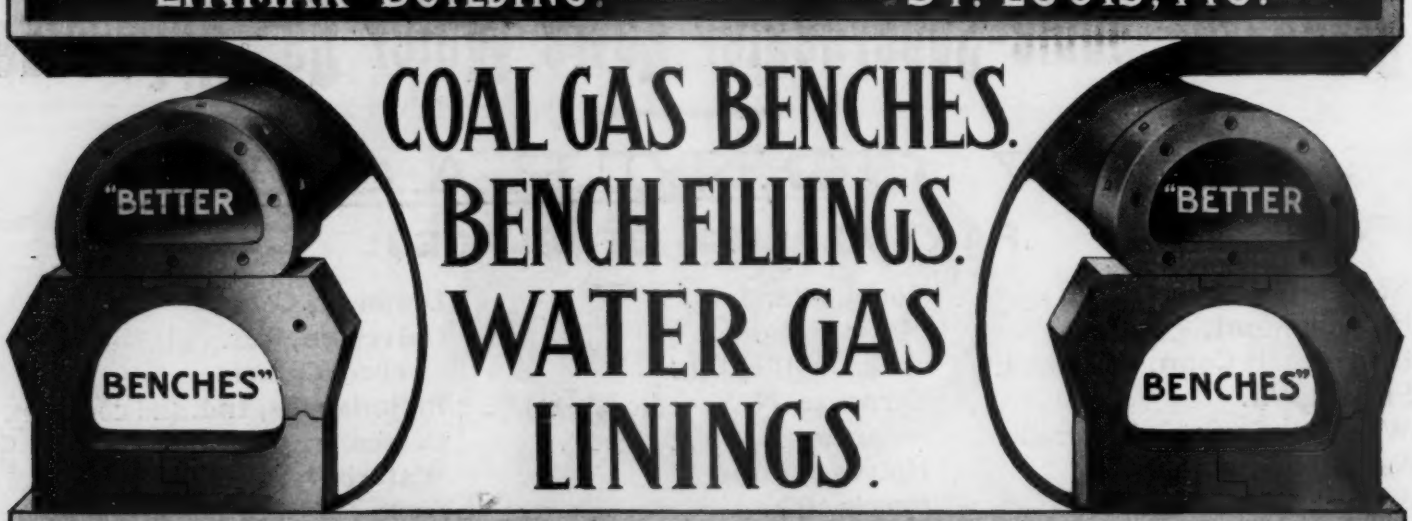

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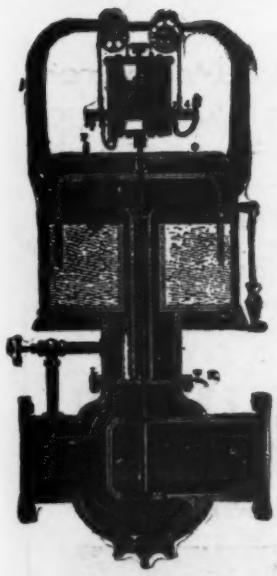

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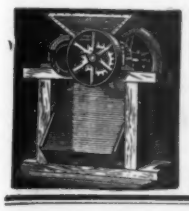

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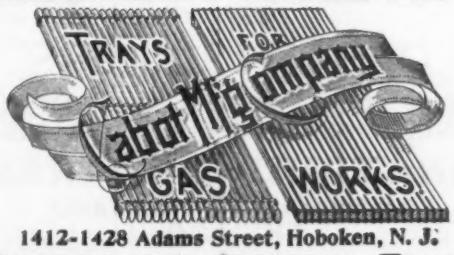

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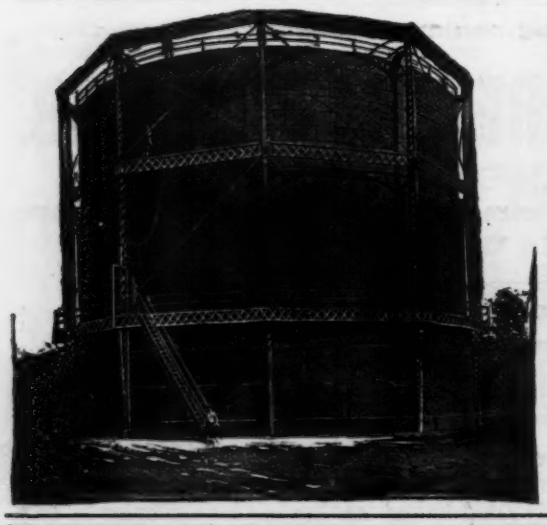

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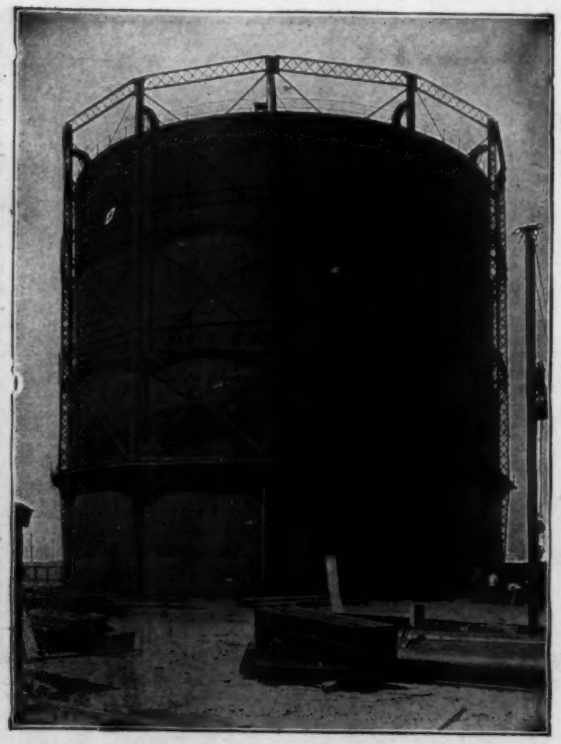

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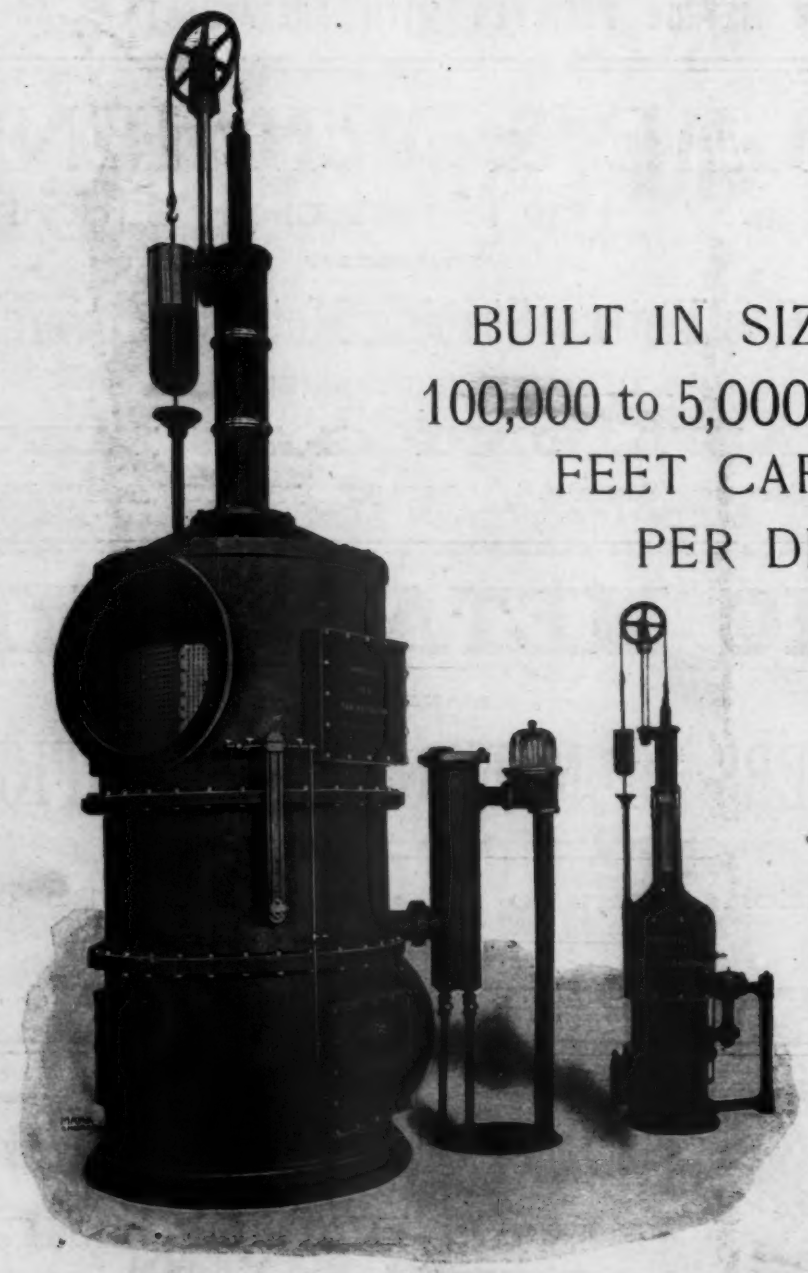

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